EurASEAA14
Volume II
Material Culture and Heritage

Papers from the Fourteenth International Conference of the European Association of Southeast Asian Archaeologists

Edited by
Helen Lewis

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Dedication

This volume is dedicated to five EurASEAA colleagues.

Mike Morwood, who passed away in 2013, had been planning to come to EurASEAA14 to give a public lecture but had to cancel because of illness. He would have given the major lecture from the conference related to the Dublin European City of Science Year, talking about – what else? – the spectacular finding of *Homo floresiensis*, for which he and his colleagues were world famous. An obituary for Prof Morwood written by Iain Davidson, a colleague at the University of New England, can be found at: <http://www.humanities.org.au/wp-content/uploads/2017/04/AAH-Obit-Morwood-2013.pdf>.

Wilhelm Solheim II passed away in 2014. Prof Solheim is best known for his work on trade and exchange in later prehistoric island and mainland Southeast Asia, such as the Nusantao Trade and Exchange Network. He was also one of the founders of institutions in Southeast Asian archaeology, such as the IPPA Congress and the Asian Perspectives journal. After retiring from an academic career at the University of Hawai'i, in his later years he was based at the University of Philippines, where he encouraged younger scholars and continued to participate in fieldwork until the last few years of his life, including research at Ille Cave, which built on some of his previous research. We were very honored to have him with the team. An obituary for Prof Solheim by Miriam Stark can be found at <http://antiquity.ac.uk/tributes/solheim.html>.

Kuang-jen (KJ) Chang was a Taiwanese archaeologist researching Philippine prehistory at the Institute of Archaeology, University College London. His doctoral thesis from 2008, supervised by Stephen Shennan and Elizabeth Bacus, was entitled 'Social use and value of trade ceramics: an analysis of mortuary practices in Calatagan, southwest Luzon, the Philippines'. Dr Chang was a very enthusiastic proponent of Southeast Asian archaeology research in Europe, and was a member of the EurASEAA14 Organizing Committee, involved in all stages of conference organization. He attended the Dublin conference in 2012, but within a year had returned to Taiwan to undergo medical treatment. He was involved with some aspects of the onset of the production of these volumes before he became too ill. The joy and energy he brought to discussions about Southeast Asian archaeology will never be forgotten.

Janice Stargardt was a fellow In Sidney Sussex College, University of Cambridge, and a professorial research fellow in Asian archaeology and geography. Prof Stargardt was always enthusiastic and encouraging about all archaeological research everywhere in Asia. Her own specialty was Pyu archaeology, including fieldwork at Sri Ksetra, but she was a font of knowledge for students and researchers working anywhere in the region. She was a very welcoming and friendly character, fondly remembered for her teaching and mentoring in addition to her research. Notes of remembrance can be seen at <https://www.southeastasianarchaeology.com/2020/01/15/obituary-prof-janice-stargardt/>.

Jeffrey Abdullah co-authored a paper in this volume on Paleolithic Bukit Bunuh. Before he passed away in 2018, he was a lecturer and researcher at the Centre for Global Archaeological Research, Universiti Sains Malaysia. Previously he was a curator at the Archaeology Department, Sabah Museum. Coming originally from an earth sciences background, his expertise was in the fields of geoarchaeology, archaeo-quaternary studies, Paleolithic culture, and lithic technology. His main research focus was on Sabah, e.g. Balambangan Cave, the Mansuli and Keningau Valleys, and the megaliths of Sabah. He collaborated on projects in the Bujang and Lenggong Valleys, and with the National Heritage Department, Ministry of Communications and Multimedia, and Sabah Museum (information from Nor Khairunnisa Talib, 2020).

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Following continuous fieldwork as an archaeologist and social anthropologist during the early seventies among the last societies representing Neolithic standards in Melanesia, **Henry Dosedla** was engaged in several development programs and documented gradual stages of cultural change including related social effects. After retiring from the German Museum of Agriculture at Hohenheim University, his research has focused on parallels between recent archaic societies and conditions in prehistoric Europe. / As bilong toksave. Planti ol saveman ol i hat wok long digim graun insait long Niugini long kisim save long taim bilong tumbuna. Na olsem sampela i bin painim kainkain longwe rot bilong ol sip i go long bigpela solwora. Na dispela rot i save lainim Niuguini wantaim sampela hap bilong Asia long taim bipo tru. Email: heinrichdosedla@gmail.com.

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Editorial introduction to EurASEAA14 Volumes 1 and 2

Helen Lewis

The Fourteenth International Conference of the European Association of Southeast Asian Archaeologists (EurASEAA14) was held in Dublin from September 18-21, 2012, hosted by University College Dublin School of Archaeology. The conference took place at Dublin Castle Conference Centre and the Chester Beatty Library, in the heart of the capital, bringing together archaeologists, art historians, ethnographers and philologists who share a common interest in the past of Southeast Asia. The aim of EurASEAA is to facilitate communication between different disciplines, to present current work in the field, and to stimulate future research. This international initiative aims to foster international scholarly cooperation in the field of Southeast Asian archaeology, art history and philology.

These volumes are rather late in publishing articles based on talks given at the 2012 conference. The articles have been updated to 2019 by the authors; several others based on the proceedings have been published elsewhere in the interim. Some of the articles in this volume have been individually refereed by anonymous reviewers, while others have not. Where a chapter has been refereed a note is made to this effect in the acknowledgements.

I am especially grateful to Michael Ryan, Jimmy Deenihan, Colin Toomey and to the late Paedar Caffrey, who arranged the donation of Dublin Castle Conference Centre and the Chester Beatty Library lecture theatre for the EurASEAA14 conference. Fionnuala Croke and Lisa Fitzsimons at the Chester Beatty Library, and Úna Kearney, Denis McCarthy and Darren Lennox at Dublin Castle enabled, informed and assisted us in many ways to make the conference possible, professional and enjoyable, in the best venue in Dublin. The donation of the conference center was the main factor that made it possible for the UCD School of Archaeology to decide to proceed with our EurASEAA14 bid.

EurASEAA strives to find funds for inviting Southeast Asian colleagues to participate in its conferences in Europe, and for EurASEAA14 we were grateful to receive a Wenner Gren Conference Grant to help meet this specific aim. This grant enabled twenty-five scholars who would otherwise not have been able to attend to come to Dublin from Southeast and South Asia, by meeting part-costs for each of them. In addition, the conference was able to waive fees for these scholars, on the basis of earmarking contributing funds coming from conference fees. We were also able to offer day rates and student discounts, which enabled many more people from Ireland and the EU to attend at least part of the conference. Additional financial assistance was provided by the Irish Research Council, which helped to support the excellent conference assistance work of Kim Rice for several months, and through assistance from the UCD College of Arts and Celtic Studies for digital recording. The UCD Finance Office and Research Office provided enormous assistance, and the College of Arts and Celtic Studies provided management of funds and significant advice regarding online payments, accounting, and bank arrangements, and I am particularly grateful to Niall McLernon for his help in these matters. The School of Archaeology administered day-to-day payments and accounts, and established and ran the EurASEAA14 website, which was designed by Phoebe France, with later additions and modifications by Robert Sands. I am extremely grateful for the support and help of all my colleagues in the School, and particularly to Angela McAteer, Conor McDermott, Rob Sands, Tadhg O'Keeffe, Muiris O'Sullivan and Gabriel Cooney for their ideas, their know-how, and their time.

EurASEAA held its first conference in London in 1986, and the biannual conference has since moved around various European cities. There have been EurASEAA conferences in Belgium (Brussels 1990), France (Paris 1988 and 1994, Bougon 2006, Nanterres 2015), Germany (Berlin 1998 and 2010), Ireland (2012), Italy (Rome 1992, Sarteano 2000), Poland (Poznań 2017), Sweden (Sigtuna 2002), The Netherlands (Leiden 1996 and 2008), and the United Kingdom (London 1986 and 2004). All the conferences are run by locally-organized committees, but with substantial assistance and advice from the EurASEAA Executive Committee. For EurASEAA14 a conference academic committee was established to make decisions about panel, paper and poster proposals, and I would like to formally thank my colleagues who served on this committee: the late KJ Chang (then at University College London), Peter Lape (University of Washington), Victor Paz (University of the Philippines), Alan Peatfield (University College Dublin), and T. Oliver Pryce (then at University College London). In addition, Valérie Zaleski and Arlo Griffiths helped with the epigraphy papers. I am also very grateful to the Executive Committee from 2010-2019 for choosing UCD and Dublin in 2012, and for their continued help over the conference and publication period, especially Lis Bacus, Alex Green, John Guy, Pierre-Yves Manguin, Mai Lin Tjoa-Bonatz, Marijke Klokke, Bérénice Bellina and Oli Pryce. I am also grateful for discussions with Vince Pigott, Roger Blench, and the late Ian Glover.

For EurASEAA14 we invited papers and panels on any topic or theme related to Southeast Asian archaeology, including papers on South Asia and East Asia, which are important for issues of long-distant contact and regional modelling. As 2012 was also the year that Dublin was European City of Science, we proposed one special theme on 'Science, Archaeology and Heritage in Southeast Asia', which stimulated the submission of themed panels on archaeobotany, geoarchaeology and human bioarchaeology, as well as several papers specifically related to science topics in other panels.

Proposed panels ranged widely in topic, covering many themes in Southeast Asian regional archaeology. In addition, at the fourteenth international meeting we included a more formally-structured set of panels on epigraphy and manuscripts, the former through an initiative from within the Southeast Asian epigraphy community, and the latter primarily through the links of one of the conference's host institutions: the Chester Beatty Library, which is home to a world-class collection of manuscripts, notably studied by the late Henry Ginsburg of the British Library. There was also a special focus at EurASEAA14 on Southeast Asian ceramics, building on momentum from an international workshop hosted by the University of Pennsylvania Museum and Smithsonian Institution in late 2010, and two panels on Khmer archaeology, including one specializing in Khmer stone materials which was funded by the Edward W. Forbes Fund, Freer Gallery of Art, Smithsonian Institution. I am very grateful to Janet Douglas and Stacy Bowe at the Smithsonian Institution for organizing the latter and dealing with the funding issues involved from the US end. Additional sub-regional panels related mainly to certain important 'peripheries', 'crossroads' or 'boundaries' of Southeast Asia – Taiwan, Myanmar and northeast India – which brought a focus on these areas of interaction, continuing some of the themes of the EurASEAA13 conference in Berlin related to crossing borders and connections (Tjoa-Bonatz *et al.* 2012a-b). I am very grateful to all of the panel proposers and organisers for their efforts and expertise. The papers presented in this two volume set represent most of the conference panels.

I am also very grateful to the key-note speakers at EurASEAA14 – Joyce White and the late Claude Jacques – who spoke about the future and past of Southeast Asian archaeology and historical research. In addition, we had three special public lectures hosted by the Chester Beatty Library as part of the Dublin City of Science festival, by Charles Higham, John Miksic and Hiram Woodward. Charles Higham's lecture was supported by a book launch event hosted by River Books. Finally, we held a special public seminar hosted by UCD School of Archaeology, given by Matthew Spriggs. All these events were extremely well-attended and well-received, and were aimed at promoting Southeast Asian archaeology and historical studies to the public and scholarly communities in Ireland. I am very grateful to all the special lecturers

involved in these events, which truly enriched the conference and inspired in so many ways, and to Gabriel Cooney and Alan Peatfield for hosting the Chester Beatty archaeology lectures.

The following individuals helped to promote the conference, and donated their time and expertise to organizing the website, social events and conference discounts, fundraising and outreach to the local community in Dublin and Ireland: Kim Rice, Patrizia La Piscopia, Margaret Williams, David McGahan, Hjayceelyn Quintana, Martin Murray, Piet Patricio, Chris Flynn, Edy Muttaqin, Denis O'Reilly, Elaine Hickey, Susan Delahunty, Aibhe Roche, Steve McPhilemy, Anne-Marie Diffley, Sheila Dooley, Jim Quinn and Martin Kelly. I would particularly like to thank Terry O'Hagan and Stephen Harrison for donating their time to give conference tours, and Kasper Hanus for his time and help with technology in the Chester Beatty panels. I am also very grateful to all our panel organizers, chairs, and speakers for their participation, for local fund-raising initiatives, and their logistical savvy. Kim Rice, Patrizia La Piscopia and Margaret Williams are stars for being delegated with major tasks, and I am thankful to all our volunteers in Dublin for their help and enthusiasm in all manner of things. And for reading and re-reading (and re-reading) the abstracts for copy-editing, I am very grateful to Yvette Balbaligo, Andrew Cowan and David McGahan, and to Rob Sands for continually updating them online. Rob Sands and Conor McDermott managed the website, promotional materials and the putting together of the abstracts booklet; without their expertise the conference would not have been possible.

Finally, I would like to express my gratitude to all the contributing authors of these volumes, and my apologies to those who contributed but had to withdraw due to the time delay in publication, for which I take full responsibility. I am extremely grateful to the anonymous colleagues who were involved in the lengthy process of refereeing, where this happened. The following individuals assisted in the production of these volumes: Michael J. Allen, David Davison and Ben Heaney at Archaeopress, Jonathan Kress, Peter Lape, Neal Matherne, Muiris O'Sullivan, Victor Paz, Alan Peatfield, Vince Pigott, Denise Riordan, and the late KJ Chang. I apologise if I have inadvertently forgotten anyone: as is obvious, the production of the conference and proceedings was the joint effort of many dedicated individuals.

Publication of these proceedings was funded wholly through EurASEAA14 conference fees, contributed by all paying attendees.

Introduction to this volume

This is one of two volumes comprising papers originally presented at EurASEAA14 in 2012 but updated to late 2019 for publication. This volume focuses substantially on topics under the broad themes of archaeology and heritage, material culture, environmental archaeology, osteoarchaeology, historic and prehistoric archaeology, ethnoarchaeology, and long-distance contact, trade and exchange. Because many of these topics are far outside my own expertise, I have relied heavily on the included authors and, where possible, referees, for advice on spellings and correct presentation of names etc., and I apologize to the authors for any remaining errors on these fronts.

Ceramics from the Musi riverbed

John N. Miksic

Riverine archaeology in Southeast Asia is gravely underdeveloped. The Musi River has been a major artery of commerce for two thousand years. The local adaptation to the area's swampy, flood-prone environment has been to live on stilt houses over water, on ships, and on rafts. This pattern of settlement presents special problems for archaeologists. It is likely that a major proportion of the area's archaeological heritage lies on the riverbed. This source of archaeological data has never been systematically explored, and unless something is done urgently it will be lost forever.

Riverbeds and harbors as sites of cultural heritage

The study of underwater cultural heritage focuses mainly on cargoes of shipwrecks beneath saltwater. Shipwreck archaeology in Southeast Asia has experienced major advances in the last fifteen years, but the archaeology of ports and other sites at the place where land and sea meet, such as shipyards, lags far behind. In Sumatra, seaports can be located over 100 kilometers from the mouths of rivers and estuaries (Figure 1). For example, the port of Jambi is 120 kilometers up the Batanghari, which is still tidal at this point. Palembang, the ancient capital of Sriwijaya, one of Southeast Asia's greatest maritime kingdoms, lies ninety kilometers up the Musi River, still within the tidal range.

Very little archaeological research has been carried out in Southeast Asian ports. Such sites pose special challenges to archaeology. Their stratigraphy is rarely well-preserved. Environmental factors include floods, tides, tsunamis, rapid sedimentation interspersed with erosion, river course change, and human activity such as construction of piers and warehouses, which are often built of temporary materials subject to rapid weathering, constant repairs, expansion, and other alterations. The most common artifacts found at ports are pottery fragments and organic materials such as wooden pillars for piers and dwellings. Large quantities of such remains are needed in order to draw accurate statistical inferences about the past.

The waters off southeast Sumatra have attracted increasing attention from maritime archaeologists. Several sites of shipwrecks near the Karimata and Gaspar Straits and the western Java Sea dating from the ninth and tenth centuries CE have been studied (Miksic 2013). Land-based archaeological research in Palembang and environs has yielded important evidence of ceramic imports from China starting in the Tang Dynasty (see below). One potentially important source of archaeological data has yet to be tapped: the bed of the Musi River in Palembang, site of Sriwijaya's capital in the ninth century CE. This river has been a major artery of commerce for 2000 years. It is likely that a major proportion of the area's archaeological heritage lies on the riverbed. A wide range of artifacts dating from the fluorescent period of the kingdom of Srivijaya (roughly the ninth and tenth centuries) has recently appeared on the local antiquities market. Among these are various types of Chinese ceramics. One particular bowl has been identified by some Chinese archaeologists and art historians as an example of *mise* or 'secret color' ware (Lim Yah Chiew 2011). The definition of this term as well as the provenance of this artifact are conjectural, but this unusually fine object is probably representative of the intimate relationship between Srivijaya and China in the ninth century, and of the quality of historical material which is being lost.

Figure 1. Early Southeast Asian ports. Image courtesy of Goh Geok Yian.

Archaeology of ports in Southeast Asia

In southern Thailand the site of Khao Sam Kaeo has yielded evidence of port activity as early as the third century BCE (Bellina-Pryce and Silapanth 2006). Excavations at Sembiran in north coastal Bali have yielded important remnants of port activity on a sandy beach which is now being rapidly eroded. Discoveries include fragments of Romano-Indian rouletted ware made in south India during the period 200 BCE-200 CE (Wayan Ardika and Bellwood 1991). DNA from a 2000-year-old skeleton found at Sembiran has been identified as possibly Indian, although this conclusion has been disputed (Wayan Ardika *et al.* 1997; Lansing *et al.* 2004, 2006; McLauchlan and Thomas 2006). The site of Óc Eo in south Vietnam, Southeast Asia's largest port of the early historic period (third to early seventh centuries CE) was investigated in the 1940s (Malleret 1959-1963), and again in the 1990s (Manguin 1998). It lies in a swampy, flood-prone area, where some organic remains were fortunately preserved.

The oldest dated boat found in Southeast Asia was discovered in a river in peninsular Malaysia, at the site of Pontian, Pahang, where it seems to have been preserved by a sudden slumping of riverbank soil about a mile from the coast (Evans 1927: 94). The timbers of the Pontian ship belong to varieties found from Cambodia to the Malay Peninsula and Indonesia (Gibson-Hill 1952). Radiocarbon analysis found that the trees for building the ship were felled between 260 and 430 CE (1657 ± 60) (Manguin 1993b: 256). Malaysian archaeologists have initiated research at several important port sites. Excavations at Kuala Selinsing, a group of mounds surrounded by mangrove swamp first investigated in the 1920s (Evans 1932), have shown that the area was inhabited approximately two thousand years ago, and continued

in use for a millennium (Nik Hassan Shuhaimi Nik Abdul Rahman 2013). Pengkalan Bujang near the foot of Kedah Peak, an important port in the twelfth century, was investigated in the 1950s, but only a preliminary report was ever published (Lamb 1961). In 2010 the Malaysian government allocated a sizeable quantity of funds for research in south Kedah. Sungai Batu has yielded major discoveries, including large brick structures which Malaysian archaeologists believe were used as landing stages for boats. These seem to date from the early to mid-first millennium CE (Shamsul Anwar Aminuddin *et al.* 2011). The Bujang Valley Museum displays a number of well-preserved hulls from sites in south Kedah. No radiocarbon dates on them have yet been published; this data would be of great potential significance. The boats are of the lashed-lug design characteristic of early Austronesian boatbuilding (Manguin 1993b).

In the coastal plain of west Java, the site of Batujaya has yielded significant evidence of Buddhist activity in the early first millennium CE (Manguin and Indrajaya 2006). No evidence of a port or non-religious activity has, however, yet been located there. In Singapore, numerous sites of fourteenth-century activity have been studied. One of these, Empress Place, lays on the ancient bank of the Singapore River. In 1998 the intertidal zone was excavated. Artifacts recovered included a wide range of ceramics, metal objects, and some organic materials, including poles which had perhaps been used for tying up boats (Miksic 2013: 245-252). The former capital of the Sultanate of Brunei was a trading site and capital from around 1400-1580 CE, when a Spanish attack destroyed it (Harrisson 1970). Further study of this site could yield greater understanding of one of the most important Southeast Asian trading kingdoms of the fifteenth century.

Somewhere in the Batanghari valley, possibly at a location now called Muara Jambi, the capital of a very rich and cosmopolitan kingdom must exist. Archaeological research in the province has focused on Muara Jambi, about twenty-five kilometers down the Batanghari from the modern capital of Jambi Province, where thirty-nine *caṇḍi* or brick temples have been recorded (Mohamad Nazir 1980-1981: 23). Archaeological evidence of trade in Jambi consists of Chinese porcelain ranging from the Five Dynasties through the Yuan period (ninth to thirteenth centuries CE), scattered over a number of sites between Muara Jambi and the sea (Edwards McKinnon 1982a, 1982b, 1992a, 1992b; Abu Ridho 1992, 1995). A survey project in 2006 concentrated on looking at exposures in the banks of the river at low tide, and identified numerous sites of the eleventh and twelfth centuries (Miksic no date). Several hundred kilometers further upriver, recent excavations have revealed complexes of brick ruins associated with Chinese pottery of the thirteenth and fourteenth centuries (Lucas Partando Koestoro 1999). It seems that an important settlement developed at this location, functioning as a connecting point between highland collectors of forest products and minerals including gold, and trading partners in Southeast Asia and further afield.

At Kota Cina, near the mouth of the Deli River in northeast Sumatra, abundant remains of entrepôt activity of the late eleventh through mid-thirteenth century have been recovered, including Buddhist and Hindu brick structures, stone statuary, Chinese coins and pottery, and local ceramics. Preserved house posts and many post molds were recorded (Edwards McKinnon 1984; Miksic 1979). Unfortunately, the probable location of the port itself, a silted-in harbor, was destroyed through excavation of soil for a modern construction project. Remains of ceramics of the eleventh to thirteenth centuries and associated ship timbers were observed during the digging in the Hamparan Perak area (Edmund Edwards McKinnon, personal communication, 2006). The only early port yet excavated on the west coast of Sumatra is Barus. The center of activity in the area seems to have shifted between several locales within this general area. Artifacts found here date from the tenth century to the present, and include many imports from the Persian Gulf, India, and China (Guillot 1998; Guillot *et al.* 2003; Perret and Surachman 2009).

Karangagung

In the lowlands of southeast Sumatra, a site which may have been a port between 1 and 500 CE has been located at Karangagung, between the Musi and Batanghari rivers (Soeroso 2002; Jayanegara *et al.* 2008). Excavations there since 2001 have provided important data for the study of pre-Srivijayan commercial activity. Many artifacts including beads and gold had been looted, but finds of jewelry, such as bronze and glass bangles, and pendants, and preserved house pillars indicate that a large settlement or series of settlements existed here, radiocarbon dated to 220-440 CE (Manguin 2004: 287-288). Artifacts recorded include carnelian beads, rock crystal, a shiny black stone which may be onyx, and glass beads of several styles.

Director of the archaeological office for South Sumatra, Nurhadi Rangkuti (2009-2010), established a website devoted to the development of wetland archaeology in Indonesia; the website read in part: 'Lahan basah yang mencakup rawa pasang surat, rawa gambut, rawa bekalang sungai, hutan bakau, danau, lagun, dataran banjir sungai dan lainnya pernah menjadi tempat bermukim manusia masa lalu. Pusat peradaban kuna jug muncul dari lahan basah. Penelitian, pelestarian dan pemanfaatan situs-situs arkeologi di lahan basah sudah waktunya diprioritaskan untuk mengungkap kejayaan maritime bangsa Indonesia' [Wetlands which comprise tidal swamps, swamps with acid soil, back swamps, mangrove forests, lakes, lagoons, flood plains etc. in the past were locales of human habitation. Ancient centers of civilization also arose from wetlands. It is time that research, conservation, and exploitation of archaeological sites in wetlands be given priority to expose the success of Indonesian maritime people]. This proclamation deserves commendation and support where possible.

Palembang and the Musi riverbed

The kingdom of Srivijaya rose to prominence in the late seventh century CE, and for the next 350 years dominated the shipping route carrying monks, merchants, and immense quantities of luxurious merchandise between the Indian Ocean and the South China and Java Seas. Between 682-686 CE, several large inscriptions were set up in Palembang and vicinity (Manguin 1987). The wetlands around Palembang have yielded remains of two boats of the first millennium CE, one dated to 610-775, with a length estimated at twenty-six meters, and one dated 434-631 (*ibid.*). The relative dearth of archaeological material in Palembang and vicinity has occasioned much comment among archaeologists and historians. The rather unprepossessing results yielded by dryland archaeology do not seem commensurate with the glowing descriptions of the wealthy port kingdom found in Indian and Chinese sources (Bronson and Wisseman 1976; Wolters 1979).

Modern urbanization has probably obliterated most of the remains of Srivijaya which stood on dry land. For example, the left bank of the Musi (termed the *hilir* area in Palembang nomenclature) next to Pulau Kemaro is occupied by a huge urea fertilizer plant owned by PT Pupuk Sriwijaya (Pusri), the state fertilizer company. Indonesian archaeologists are convinced that the site of the factory was formerly a major area of Sriwijayan activity (Dr Mundardjito, 1988, personal communication). Caṇḍi Gede Ing Suro and Caṇḍi Penembahan, where brick structures dating from the fourteenth century CE were converted into graves for Islamic-period rulers and their consorts (personal observation 2011), are located next to the fertilizer plant. In 2011 a brick wall was erected next to Caṇḍi Gede Ing Suro, forming a barrier between the site and the fertilizer plant. Within this walled area lies a complex of earthen ramparts of substantial extent, bounded by a stream which leads directly to the Musi River (Figure 2). This may have been part of an ancient site.

Another reason for this discontinuity between text and material remains is probably the loss of much of Srivijaya's material culture due to ancient use of perishable materials and the local habit of living on rafts or stilt houses above flowing water (Manguin 1987). Nevertheless, archaeological research in and around

Palembang has now yielded enough data to confirm the earlier assumption that Palembang was Srivijaya's capital from the seventh to eleventh centuries (Manguin 1992, 1993a).

Much of the remaining archaeological potential of Palembang probably lies beneath the Musi River. History and ethnography suggest that the nobility of Sriwijaya lived on dry land, whereas much of Sriwijaya's population lived on water, either on stilt houses or on rafts (van Sevenhoven 1825; Wallace 1869). Evidence of their existence as well as port activity such as warehousing and transshipping of cargo therefore is likely to be in the mud beneath the river.

Figure 2. Earthen ramparts near Gede Ing Suro, 2011. Photo: J. Miksic.

Figure 3. Musi River, Palembang. Photo: J. Miksic.

Fishermen have recovered a large quantity of artifacts from the Musi riverbed (Figure 3). A similar phenomenon was reported for the upstream area of the Batanghari, near Padangroco (Budi Istiawan, 16 November 2011, personal communication), where the fishermen use *kapal dompeng,* boats equipped with suction devices which bring up quantities of riverine sediment, including artifacts. A reconnaissance trip to Palembang in May 2011 indicated that a wide range of artifacts was still within easy reach on the riverbed, but that supply was already steadily diminishing. Local men were diving in the Musi River using primitive equipment, at times when the tides and currents balanced each other, to obtain ancient artifacts. During this trip we were shown a wide assortment of ceramics, beads, bronze articles, coins, old wooden implements, and gold objects. As news of the presence of foreign visitors to the homes of the fishermen where artifacts were kept spread through the neighborhood, groups of divers came to offer wares obtained in the river for sale. It appeared that a significant number of men were pursuing this activity as a semi-regular occupation; using only goggles and a hose for compressed air, they probed the muddy bottom with iron rods, which often cause serious damage to artifacts.

We were only shown the least valuable items. The more saleable pieces were no doubt quickly disposed of through networks leading to Jakarta, where most Indonesian antique collectors and people of means live. Yet even among the dregs of the treasures lying under twenty meters of water and a meter of river mud lie objects which hold the potential to clarify many details of our knowledge of early shipping activity in Southeast Asia. For example, the divers had acquired a range of small gold items (Figure 4). Sumatra was known as *Suvarnadvipa* ('Golden Island') in ancient India (Wolters 1979), and numerous sources of gold are known to exist in the hinterland of Palembang. These items, including locally made coins and pieces of jewelry, belong to types found in central Java and dated to the late first millennium

Figure 4. Gold ear ornament, two centimeters high. Photo: J. Miksic.

Figure 5. Head of Buddhist deity, stone; height c. thirteen centimeters. Photo: J. Miksic.

CE (cf. Miksic 2011). Their collections also contained large quantities of beads of glass and stone in addition to gold examples. Religious objects included numerous items associated with Buddhism. In addition to bronze statues of Buddha (Figure 5), there were examples of what appear to be stamps used to print Buddhist texts on clay. More research on these is needed to clarify their significance.

Decorative bronze items were also present, among them several faces of Kala, mirrors, and bells with *vajra* handles for use in esoteric Buddhist rituals. Cylindrical amulet containers meant to be suspended from strings hung around the neck were made of gold. Other rolled-up pieces of heavier metal may have been tin or lead votive objects inscribed with sacred formulae. Utilitarian objects included scale weights. Large quantities of Chinese coins were also collected. Porcelains spanned a wide range of Chinese export wares, from Tang Yue bowls through cobalt blue decorated wares of the middle Ming period. Some examples of fine-paste earthenware, probably from southern Thailand, were also in the assemblage. Quite probably many more examples could be found on the riverbed, but since these are not generally salable, they were probably left there.

Historical and archaeological context of the *mise* bowl attributed to the Musi riverbed

At the launch of the Archaeology Unit of the Nalanda-Sriwijaya Centre, Institute of Southeast Asian Studies, by the then-President of the Republic of Singapore, S.R. Nathan, on 23 August 2011, a private collector exhibited a number of items purportedly recovered from the bed of the Musi River in the general area of Palembang where the capital of the kingdom of Sriwijaya is supposed to have existed. No direct evidence for the provenance of these artifacts was provided, but the owner had previously introduced the author of this paper to looters in Palembang, who had in turn shown sherds of similar ware. There is no reason to doubt this attribution, though it cannot be proven. Among the artifacts on display was an intact green porcelain bowl which the owner of the artifacts described as a *mise* ('secret color') bowl (Figure 6).

Major exports of Chinese porcelain began in the ninth century. A shipwreck found between Sumatra and Borneo which sank *c*. 830 CE near the island of Belitung (often called the Batuhitam Wreck) was

carrying about 60,000 Changsha bowls and other wares. One of the bowls on board is dated to 826 CE (Guy 2001-2002: 25). A few Southeast Asian artifacts had also found their way aboard the ship, indicating that it stopped somewhere in the region. A source from 841 says, 'Guangzhou enjoyed the profits of the barbarian ships where all the valuable goods were gathered....Of all those who served at Guangzhou, not one returned without being fully laden (with the wealth they acquired)' (Wang 1958: 83). Excavations by a Franco-Indonesian team at the Museum Badaruddin site in central Palembang in 1990-1991 yielded 55,000 artifacts weighing over 800 kilograms, 40% of which belonged to the Srivijayan period. Out of the total assemblage, imported ceramics comprised 10,000 items or 18% (Manguin 1992). Green ceramics of Yue type, mainly bowls, comprised a significant proportion of the imported ceramics (*ibid*.).

By the ninth century, Chinese merchants were already sojourning in Southeast Asia. Merchants were governed by harsh regulations, but local officials had some flexibility in applying the rules: 'Far across the sea in the South, there were those who died in the countries there. The officials held their goods. And if their wives or their sons did not come within three months to claim them, these would be confiscated. The governor (stopping this practice) said: 'The sea journey back and forth is calculated in years; why fix the time in months. If anyone has proof, no matter whether he comes early or late, let him have all' (Wang 1958: 101-102).

The Famensi is a major Buddhist temple in Shaanxi Province, north China, which dates from the Tang period (Anonymous 1992). The main structure surviving from the Tang period, a multi-storied pagoda, was damaged by rain in 1981 and dismantled in 1986. During this process, workers found a marble slab covering a crypt containing gold, silver, glass, silk and porcelain presented to the shrine by the Yizong emperor, a devout Buddhist who reigned from 859-873 CE. Shortly before his death, he held a grand ceremony for a relic said to have been a bone of Buddha's finger (*ibid*.); this may have been the main relic in the Famensi crypt. The crypt appears to have remained undisturbed from the deposition of the items until its dismantling. A stone tablet inscribed with an inventory of items placed in the crypt included thirteen items described as being of *mise* type: seven bowls, and six plates and cups. This inscription provides evidence that some of the porcelain items found in the crypt belonged to the *mise* class of porcelain. Two types of porcelain found in the crypt display colors which the Chinese call cyan green and lake green. Two others display a bluish yellow color (*ibid*.).

The earliest date for the appearance of *mise* ware is under debate among Chinese scholars; once it was thought that it appeared in the Five Dynasties (907-960) (Wang Qingzheng 1996). A tomb of a member of the imperial family in Kangling who died in this period contains Yue wares of the same approximate quality. It is assumed that *mise* was made in one of the Yue kilns for imperial households (*ibid*.).

In addition to the Famensi crypt inventory, Lu Guimeng, a poet who lived in the port of Suzhou and died in 881, wrote a poem entitled 'Secret color [*mise*] *Yue Yao* vessel', describing an

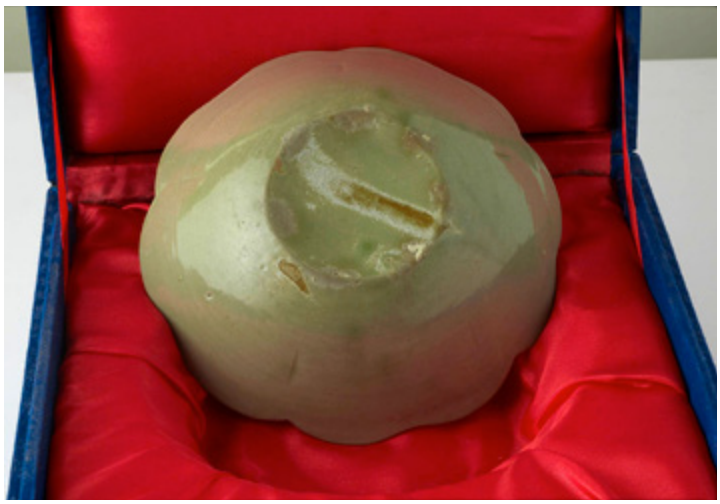


Figure 6. Green porcelain bowl purportedly found on the Musi riverbed in Palembang. Photo: J. Miksic.

item which he said was fired in late autumn. He described the vessel's color as representing the color of scenery on thousands of distant mountain peaks. Chinese ceramic experts compare this description with the imperial tributary wares made in the Hu kiln of Shanglin, Yuyao County, which were described with terms meaning 'ice-like, luscious' (Wang Qingzheng 1996). But what exactly did the word 'secret' mean in this context? Some assume that it referred to the technique of making the specific shade of green found on these objects. On the other hand, Ye Zhemin, a Chinese expert on ancient ceramics, in an interview filmed on 23 November 2011 said that the term *mise* might simply have denoted 'novelty' (<http://www.youtube.com/watch?v=8IgpWUw45kc>, viewed in 2012).

In another publication devoted to the study of *mise* porcelain, the definition of the character *mi* was debated. Although it is almost always translated as 'secret', Wang Qingzheng (1996) argued that it could also mean 'rare'. A variety of grass named *mi* is described as lake green in color. Others argue that *mi* is a mistaken transformation of *bi* (green). Another theory is that *mi* refers to a special technique of production involving the use of saggars sealed with glaze to yield a purer less yellowish green. The character *se* by contrast has universally been assumed to mean 'color', but Chinese dictionaries give an alternate definition as 'type'. Thus the cultural category of *mise* in the Tang could mean anything from 'secret or rare color' to 'secret or rare type' (I wish to acknowledge Goh Ngee Hui of the Maritime Museum of Singapore as the source of this information; see also Wang *et al.* 2014: 13, 22, 49, 72, 192).

At least half of the Famen temple ceramics thought to be those listed in the inventory as *mise* ware have concave bases. This is considered by some authorities as a defining characteristic of *mise* (Wang Qingzheng 1996)*;* only two examples of Yue ware with concave bases outside the Famen temple are known. One is a fragment of a broken bowl which is generally accepted as also being an example of *mise;* the other is in a private collection in Indonesia and is said to have been acquired in Palembang (T.K. Ngiam, 20 March 2012, personal communication). The latter bowl shares numerous characteristics with the probable *mise* ceramics from the Famensi. In addition to the glaze color, the multi-lobed shape is quite unusual. Although there is no firm consensus on the meaning of *mise* in Chinese texts, the bowl is so similar to the Famensi porcelain termed *mise* in the ninth century that it must also be *mise*. Lim Yah Chiew (2011) has argued that *mise* ware had a special Buddhist connotation. The items in Famensi included an incense burner and double-fish jar. He theorizes that the Tang emperor Yizong may have presented the bowl of *mise* type to the ruler of Srivijaya, a fellow Buddhist, for use in a temple in Palembang.

Conclusion

The provenance of the porcelain bowl with rare characteristics such as the multi-lobed shape and light green glaze with burnt-red biscuit exposed in rather haphazard fashion is unfortunately unknown. It is not improbable, however, that it was found in Palembang, where large quantities of green porcelain of the late Tang period have come to light. The best of them have entered the antique market and will never be able to be used by archaeologists to reconstruct the nature of early Sumatran society and its relationship with Chinese culture. The discovery of such an artifact, highly esteemed by experts in Chinese aesthetic appreciation, in Sumatra would reinforce and clarify the assumption that members of the Sumatran elite of the ninth century CE were able to afford and to appreciate Chinese artifacts of the most refined and subtle quality. Given the rapid rate at which this potential source of information on cultural relations is being despoiled, it is unlikely that we will ever be able to attain this level of understanding of such relations.

The staff of the Archaeological Institute of Palembang have continued to conduct archaeology in the wetlands of South Sumatra Province. Their discoveries continue to make major contributions to our knowledge of early Southeast Asian civilization. The unprovenanced finds described in this article

strongly suggest that such research should be considered a major priority. It remains to be seen whether the extra funding needed for this type of research will be forthcoming.

Postscript: In 2019 a catalogue of finds attributed to the Musi River was published (Kitchener and Heny Kustiarsih 2019). The items in the catalogue are not of the highest quality, but they probably represent accurately the types of locally made and imported items in general use in Palembang during the heyday of Srivijaya and the subsequent centuries. The usefulness of the catalogue is limited due to the lack of proven provenance, but some information about the probable types of material culture looted from the Musi River is better than none (Miksic 2019). Otherwise, there has been no change in the situation in Palembang between the time when this draft was originally written and the time of publication.

The social dynamics of porcelain trade in the eleventh to sixteenth centuries CE Philippines: a chemical composition study

Rory Dennison and Laura Junker

This research examines how the social and political dynamics in twelfth to sixteenth century CE Philippine maritime trading polities may have affected mainland Asian trading strategies within the archipelago, as examined through typological and compositional analyses of porcelain. The variable and culturally-specific social contexts in which ceramic imports were used, their significance as a form of political currency for brokering power relationships in specific Philippine societies, and the degree to which local trade networks were available to serve as intermediaries were likely factors in Chinese merchant decisions about what porcelain forms they could most profitably market, and whether both large single shipments to prominent ports and numerous 'island hopping' trade voyages were practised. This paper focuses on initial results of compositional and typological analyses using LA-ICP-MS and other techniques on porcelain from the Tanjay region of Negros Island, which allow the identification of ceramic preferences in local populations of the twelfth to sixteenth centuries, and provide evidence for differing local social valuations of porcelain and their symbolic importance in activities like feasting and mortuary rites. Ceramic groupings were identified based on associated kilns involved in production, and may distinguish Philippine settlements receiving large bulk porcelain shipments directly from foreign traders from those which relied on multiple down-the-line exchanges. Though preliminary in nature, this work offers insights into the 'demand' side of the Southeast Asian porcelain trade.

Introduction

Historical analysis of the porcelain trade in Southeast Asia using early historic records to reconstruct products, routes, and tributary dynamics has yielded crucial insights on the organization and impact of the porcelain trade on local economies (e.g. Wheatley 1961: 62-87; Doeppers 1972: 769-771; Scott 1984: 63-78; Scott 1994: 282-287). Large-scale archaeological survey has analyzed distribution ends of these trade networks in the Philippines (Hutterer 1974: 288-290; Junker 1999: 48-51) and there have been successful attempts to integrate historical textual and material avenues of study (Lape 2002: 475-478). Other works, such as Manguin's (1993b: 262-263, 270-274) examination of shipbuilding techniques in Southeast Asia, have considered the technical aspects of construction and use of seafaring vessels in the region (see also Goddio 2000). Chemical analysis of Chinese kiln ceramics, on the other hand, is an increasingly important source of information on production and distribution patterns, but so far this approach has been used only sporadically in direct comparison between source and distribution centers, and to generally compare production centers to one another (e.g. Li *et al.* 2003: 1219-1221; Zhu *et al.* 2011).

This preliminary study investigates the composition of porcelain samples found in habitation contexts at the coastal chiefly center of Tanjay, part of a broader study to examine Chinese trade conducted within the archipelago during the pre-colonial period. Rather than taking a top-down approach which privileges Chinese export strategies and their political and economic motivations in establishing certain trade patterns into Southeast Asia, this paper assumes significant agency on the side of Philippine porcelain 'consumers' that shaped these exchange systems and negotiated both forms of exchange and porcelain assemblage content on regional and local levels. The social and political dynamics in eleventh to sixteenth century CE Philippine maritime trading polities, as well as the client hinterland populations

tied to them as providers of the forest products desired by the Chinese, are crucial to understanding mainland Asian trading strategies with the archipelago. Previous historical and archaeological research on Philippine chiefdoms suggests that the culturally-determined social contexts in which trade ceramics were used (e.g. as bridewealth for high status marriages, as feasting wares for social integration and status competition, as material recompense for acts of warfare and violence), their significance as political currency among some Philippine societies (i.e. as forms of materialized alliance, patronage, and coalition building), and the degree to which local trade networks providing forest products served to successfully attract Chinese traders to certain ports, were all likely factors in Chinese merchant decision-making, marketing, and shipping practices to the archipelago (Scott 1994: 140-141; Junker 1999: 206, 298-302, 401; Barretto-Tesoro 2008).

While the project on chemical composition of imported Philippine porcelain described here also involves sourcing to kiln sites on the mainland as a means of looking at the supply or production end of the system (i.e. which Chinese producers might be manufacturing for particular Philippine markets with specific types of porcelain 'consumers'), the supply-focused portion of the project is only in the early stages of development at the time of this writing. This paper focuses on some initial results of compositional analyses on porcelain from secure archaeological settlement contexts in the Tanjay region of Negros Island (Figure 1), a region in which a small-scale chiefdom developed between the twelfth and early sixteenth centuries CE. This study uses Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) to identify ceramic groupings over time, in order to compare how trade connections may have fluctuated with a growing elite center. Though preliminary in nature, this work offers insights into the demand side of the Southeast Asian porcelain trade through its distribution pattern within the Tanjay region.

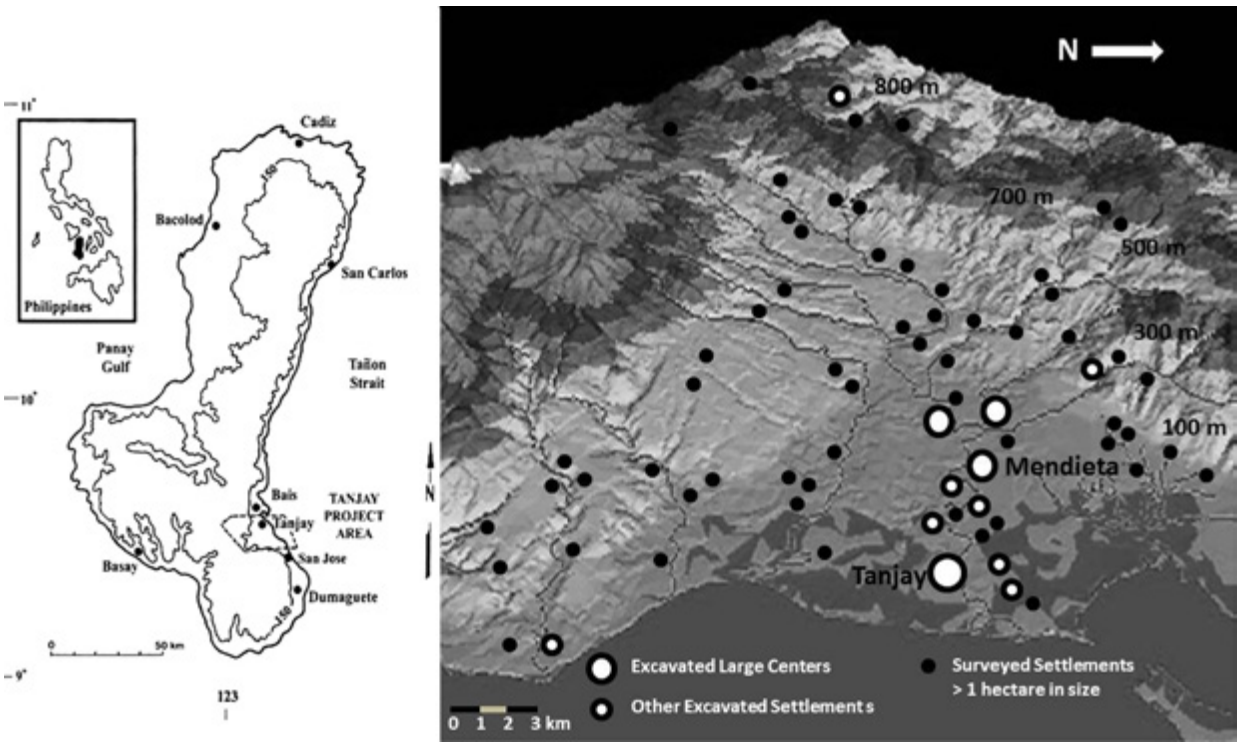


Figure 1. Location of the Tanjay Archaeological Project on Negros Island, Philippines (left) and archaeological sites larger than one hectare that have been surveyed or excavated (right). Maps by L. Junker.

Porcelain in prehispanic Philippine societies and archaeological research at Tanjay

Many exotic prestige goods entered the archipelagos of island Southeast Asia during the Early Historic Period, which saw the rise of complex kingdoms and chiefdoms spanning the ninth to early sixteenth centuries CE in the Philippines (Junker 1999: 183-220), but one of the primary and most enduring luxury items in circulation was porcelain. Porcelain was manufactured at kilns in southern China, Thailand and Vietnam (Finlay 1998: 159-160; Chuong 2005: 12, 29) and traded to and between numerous centers in Southeast Asia (Junker 1999: 202; Diem 2004: 464, 475-476, 483-485; Finlay 2010: 202-210). The Philippines served as a distribution hub in this system from an early date, as spices and forest products such as cloves were traded northward towards the mainland, and porcelain, silk and tea were in turn distributed southward (Wu 1959; Hall 1985: 205-231, 1992: 208-215). The Tanjay region of Negros Oriental in the Philippines was chosen for this initial case study in the larger research project, not because of Tanjay's status as a prominent historically-known region of long-distance trade, but because of the unprecedented volume of archaeological research carried out in the region (see Hutterer and Macdonald 1982; Junker 1990, 1999, 2002a). Historically, Tanjay is the site of a sixteenth century CE maritime trading polity smaller in scale than Manila, Cebu or Sulu, which incorporated upland tribal swiddening and foraging populations in river-based trade networks bringing forest products to the coast (Junker 1999: 17-18, 251).

The Bais-Tanjay project was one of the first archaeological projects in island Southeast Asia to use systematic regional surface survey techniques, recording more than 300 sites spanning the late Metal Age to Spanish colonial periods in the 315 km^2 region. Regional settlement pattern studies were combined with excavations of settlement remains (and in some cases burials) of various periods at thirteen sites ranging from the coastal port of Tanjay to the upland hamlets of tribal swiddeners (historically known as the *Bukidnon*) and foragers (*Ata*) at above 300 meters elevation (Junker 1999: 240-246). Porcelain sherds in the hundreds and thousands were collected in stratigraphically secure habitation and burial contexts dated in broad terms to the twelfth to fourteenth centuries CE (Sung, Yuan, Earlier Ming Period) and the fifteenth to early sixteenth centuries (Later Ming), creating a remarkable database of foreign porcelain in various local behavioral contexts (for more details see Junker 1999: 43-53).

Beginning in the Aguilar Phase (*c.* 500-1000 CE) and continuing through the Santiago Phase (*c.* 1100-1400 CE) into the Osmena Phase (*c.* 1400-1570 CE) (Junker 1990: 185), clear evidence exists of dendritic settlement patterns focused on controlling both coastal maritime-oriented trade centers, and of coast-to-interior interaction, even prior to the foreign porcelain trade (Junker 1999: 113-118; Junker and Green 2010: 11). By the twelfth century CE, the Tanjay site had grown considerably to ten to fifteen hectares in size, with Song Dynasty porcelain clearly evident. In the next centuries, Yuan and Ming Dynasty porcelains are found (Junker 1999: 201), attesting to the presence of luxury trade goods being exchanged on a large scale across the South China Sea (Junker 1990: 195, 202; for evidence from other parts of the larger region see Taylor 1992: 175; Jacq-Hergoualc'h 2002: 391-394; Diem 2004: 474-482).

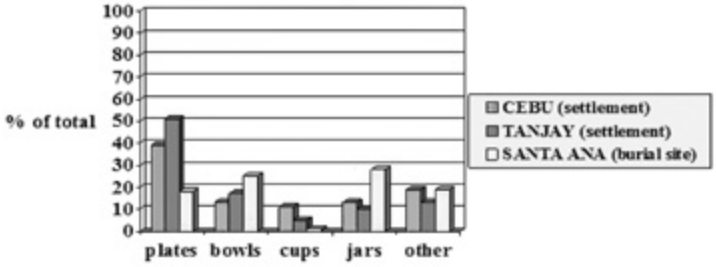
Between the twelfth and early sixteenth century CE, the archaeological evidence is strong for the presence of a highly centralized and socially stratified maritime trading chiefdom at Tanjay in both the Santiago Phase and Osmena Phase, marked by a three-level settlement hierarchy centered on the coastal port (Junker 1990: 195-198), and strong wealth differences in both burials and households (Junker *et al.* 1994: 328-329; Junker 1999: 171-179). By the fifteenth to early sixteenth centuries, in the Osmena Phase, the center at Tanjay had expanded to over thirty hectares, in tandem with archaeological evidence for expanded foreign trade, most clearly evident in the increasing volumes and diversity of foreign porcelain at Tanjay, and also at the neighboring chiefly center at Cebu (Hutterer 1973; Nishimura 1992; Junker 1999: 194-203). According to historic accounts from the European contact period and from earlier Chinese accounts, porcelain and other less archaeologically-visible status goods (such as

textiles, elaborate metal weaponry and gongs, and gold jewelry) were critical to the alliance and power-brokering activities practiced by chiefs and would-be elites (Junker 2003: 249-252), including the gifting of porcelain as bridewealth to obtain high-status wives, the use of porcelain in food presentation for status-conferring ritual feasts, and paying off warrior cadres who supported elites in warfare (Junker 1999: 292-312).

What have been interpreted as material manifestations of social hierarchies and political centralization are also associated with trends towards agricultural intensification (shown through soil, faunal and botanical studies) (Junker *et al*. 1994: 339-350; Gunn 1997: 243-245; Mudar 1997: 90-96; Green 2010: 492-530, 542-544), likely importation of labor (evidenced in rapidly increasing populations in larger and more numerous settlements) (Junker 1999: 339-343), expanding internal specialist production of earthenware and metal (Junker 1994b: 30, 1999: 279-282), escalating warfare and slave-raiding (indicated through iron weapons production and bioarchaeological studies of traumatized skeletons) (Junker 1999: 336-369, 2004: 18-20), an increasing emphasis on competitive feasting (e.g. feasting pits with charred pig and water buffalo bones mixed with broken porcelain) (Junker *et al*. 1994: 340-350; Junker 2001: 286-288; Junker and Niziolek 2010: 34-36), and more intense interactions with interior foragers and tribal swidden farmers (traced through the volume of goods moving between the inland and coast) (Junker 1996: 404-406, 2002a: 229-238; Gunn 1997: 209-261). These symbiotic trade relationships with upland swidden farmers and foragers, that involved the upriver flow of lowland manufactured metal goods and earthenware, but also occasionally porcelain, were used to extract the forest products needed to fuel long-distance trade with imperial groups for elite prestige goods such as porcelain (Junker 2002a; Junker and Green 2010: 13).

The types of tradeware vessel forms changed considerably over time in the Philippines. In twelfth to fourteenth century CE contexts at Cebu, Santa Ana and Tanjay, vessel forms were fairly evenly distributed between plates, bowls, cups, jars and other forms (Figure 2). However, in the fifteenth to sixteenth centuries, the types of vessel forms shift to strongly favor bowls and plates over cups, jars and other forms (Junker 1999: 200-204). This suggests that in later periods, foreign production shifted to try to better meet the demands of the local elites who favored plate and bowl forms for their uses in feasting contexts. Similarly, by looking at a hierarchy of settlements and the presence of different types of prestige ceramics, it can clearly be seen that there was greater access to higher-quality ceramics at larger elite sites such as Cebu and Tanjay, when compared to secondary sites and

Distribution of Porcelain Forms at 12th–14th Century Sites in the Philippines



Distribution of Porcelain Forms at 15th–16th Century Sites in the Philippines

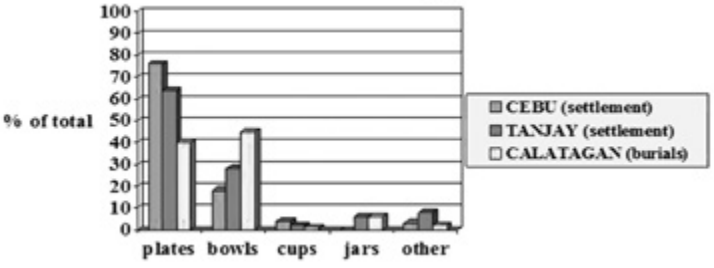


Figure 2. Graphs showing the relative concentrations of vessel forms in applicable Philippine polities during the twelfth to fourteenth and fifteenth to sixteenth centuries. Vessel forms are fairly evenly distributed between various types with only slight variation between sites in the earlier period, and show a strong shift towards plates and bowls, which were used for feasting activities, and a decline in cups, jars and other forms in the later period. Graphs by L. Junker.

upland sites (*ibid.*: 218-250), and between elite and non-elite areas within sites (Junker 1994a: 242-243). This suggests direct trade between foreign powers and Philippine polities was conducted at centers, and then dispersed by local elites to other settlements.

Early historical sources for Chinese interaction with the Philippines are brief, but show that by the Song Dynasty (960-1127 CE) imperial texts begin to mention specific names of ports and descriptions of Philippine chiefs and their polities as locations of visit and tribute by officials (Hirth and Rockhill 1911: 159-162; Guerrero 1966: 15; Scott 1984: 63-75; Zaide 1990 1: 9-13). In these texts, chiefs were recorded as making tributary missions to the Chinese court in order to offer spices, marine delicacies and equatorial forest products in exchange for gifts of silk, porcelain and prestige goods. Tributary missions from the Philippines are recorded as occurring from approximately the eleventh to fifteenth centuries CE (Scott 1984: 66-67; Junker 1999: 18, 33, 112-120). These missions, and the prestige goods with which elites returned, greatly expanded the status and influence of chiefs, and were influential in transforming aspects of chiefly political economies (Junker and Green 2010: 7-8). The peak of direct porcelain trade between the Philippines and China occurred in the Song and Yuan dynasties (*c.* 960-1368 CE) (Junker 1999: 190-191). Within the porcelain trade of the Philippines, celadon was initially prized over other styles by Philippine polities (Wilson 1988: 54-55). However, by the beginning of the fourteenth century CE local trends and variations in market production caused blue-and-white wares to grow in popularity (*ibid.*: 35, 100-102).

In the Ming Dynasty, 1368-1644 (Lili 2010: 157), foreign trade from China was brought under court control and eventually so heavily curtailed that it officially nearly ceased, though trade through illegal or imperially unsanctioned means appears to have continued through the period commonly referred to as the Ming Gap (Wilson 1988: 39, 45; Brown 2009: 27-29). Later colonial records also mention Chinese merchants in Manila, and trade between chiefdoms and sultanates at locations such as Luzon, Cebu, and Sulu (Chen 1966: 246-247; Scott 1984: 84-86; Junker 1999: 204-206; Wills 2010: 51-54; or see for example Pigafetta 1521 (1975): 55; 'Relation of the Voyage to Luzon 1570' in Blair and Robertson 1903: 82-104). The manufacture of specific pieces for foreign markets, such as crafting starfruit-shaped bottles for the Philippines to match with local fruits not common in China, is clearer in this period, partially due to an increase in historical records (Collins 2000: 118), but this process can be seen in earlier times as well. Chinese kilns of the later colonial period produced ceramics in non-traditional styles, foreign vessel forms, and using motifs (such as European heraldic devices on porcelain dinner ware) that were not favored within China itself, specifically for the export industry (Wen-Chin 1988; Finlay 2010: 27-28).

Methods of compositional analysis

In this preliminary study, samples from within the large coastal center of Tanjay were analyzed chemically, with the assumption that porcelain sherds with closely matching compositional signatures derive from distinct production sources in China or elsewhere. Furthermore, the derivation of the different porcelain types can inform us about their relative social valuation, relative exclusivity of access, and the types of local social networks within which these prestige goods were exchanged.

Porcelain samples were chosen from excavated contexts within Tanjay at two locations yielding the remains of both ancient pilehouse features and pit burials: the Santiago Church locale and the Osmena Park locale, 200 meters away (Figure 3). Based on differences in the size of the pilehouses, the presence of ditch-and-stockade houseyard features, and the richness of the artifact assemblages (densities of porcelain, fancy earthenware, bronze and iron objects and rare exotic beads and ivory objects), Junker (1999: 151-158; Junker *et al.* 1994) identified the Santiago Church locale as a probable 'elite' residential zone in the fifteenth to early sixteenth centuries, and perhaps earlier. In contrast, the Osmena Park locale yielded smaller pilehouses lacking fortification, and yielding debris with less dense concentrations of

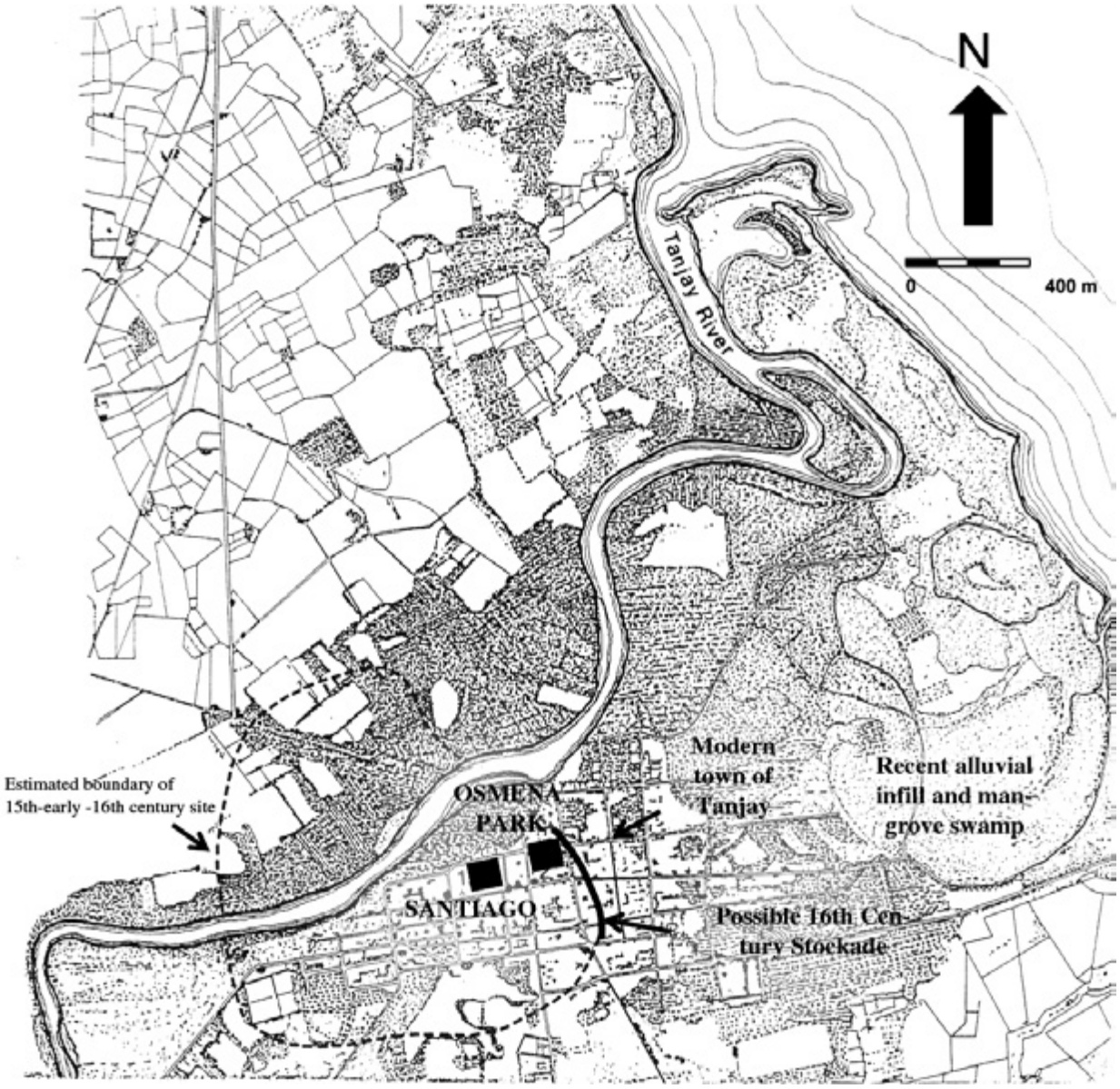


Figure 3. Map of the Tanjay Site illustrating the location of the Osmena Park and Santiago Church excavations. Map produced by S. Dennison.

porcelain. These disparities in household wealth were mirrored in the quantity and quality of burial goods in the graves associated with the houses, with the Santiago Church burials consistently yielding more and better-quality porcelains and metal (Junker 1999: 171-179). In addition, houseyards in the Santiago Church zone contained what we refer to as 'feasting pits', with significant concentrations of bones of water buffalo and pig, and other feasting foods, associated with broken porcelain serving pieces (Junker *et al.* 1994: 340-350; Junker and Niziolek 2010: 34-36).

Selection of porcelain samples for chemical analysis focused on obtaining representative pieces from securely dated habitation contexts, preferably house features such as trash pits or middens, from both major occupation phases (the roughly twelfth to fourteenth century CE Santiago Phase and fifteenth to early sixteenth century Osmena Phase). However, samples were prioritized on the quality of the contextual information, the appropriateness of the sherd size for LA-ICP-MS analysis, and whether there

were multiple porcelain sherds that could be compared in a single context. In this stage of the analysis, no burial porcelain was selected, with plans to add vessels in mortuary contexts for comparison at future stages of this research. Porcelain samples from these variable household contexts offered a good opportunity to examine the differing strategies for obtaining porcelain, and for using it to leverage social and political relationships, among porcelain consumers of differing social rank.

Samples beginning with a PSC code are from the hypothesized elite residential zone of Santiago Church, while the POP labelled samples are from lower status houses of Osmena Park. The samples studied from the two sites were selected to represent the two chronological periods: PSC001-7 and POP001-3 date to the fifteenth to sixteenth centuries CE, while PSC008-12 and POP004-8 date to the thirteenth to fourteenth centuries. All porcelain samples chosen from Tanjay were excavated from secure stratigraphic contexts which have had radiocarbon dates on charcoal from associated hearths and midden pits (Junker 1999: 397, 416). Six additional samples from Bacsije, Carcar, associated with the Cebu polity were used as a comparative group (labelled PBN and PBC). This site dates to between 1290-1400 CE (A. De la Torre, Archaeology Division, National Museum of the Philippines, 2012, personal communication). PBN001-4 and PBC001-2 are all from excavated habitation contexts and were found in association with shells, earthenware, decorated earthenware, a metal fragment and animal bones. All except PBN004 stylistically appear to be Yuan or Ming dynasty production and are blue-and-white glazed. PBN004 is green glazed and from a deeper deposit thought to be from an earlier occupation period (*ibid*.).

Statistical techniques including cluster analysis, bivariate plots and principle component analysis were used to examine grouping patterns, using GAUSS Runtime™ software and Microsoft Excel™. For the LA-ICP-MS analysis, fifty-eight elements were measured using procedures developed by Dussubieux *et al.* (2007: 351-356), based upon Gratuze (1999: 870-875). The averages were corrected using blank readings and Si as an internal standard. These readings were then transformed into parts-per-million (ppm). The elements P, Cl, Ag, In, As, Bi, Na, Au, Si and Se were removed since they tend to measure poorly or were not represented well in the samples (Laure Dussubieux, personal communication, 2012). Parts-per-million values were converted to base-10 logarithms to create a more normally distributed scale. These values were used to create dendrograms using cluster analysis to examine basic grouping patterns. Because of the small total number of ceramics in this dataset, only a limited number of elements could be included for any principal component analysis in order to avoid issues inherent to high variable and low population datasets, so the dataset was examined through a series of bivariate plots to investigate which elements would have a greater effect on variability, and to help distinguish between possible groups. Cluster analysis generated scatterplots of the sherds, which were examined to explore which elements best represented grouping patterns. As such, Li, B, Sc, Rb, Yb, Cs, Dyl, Tml, Ybl, Hf, Ta and Pb were chosen for a principal component analysis utilizing twelve variables and twenty-six samples.

Results of compositional analyses

The data were initially explored through a series of bivariate plots focusing on elements that appeared to most clearly separate the groups. Though there was overlap at the 90% confidence interval, the Santiago Church and Osmena Park locations appear to group separately when compared (Figures 4 and 5). Generally, the scatterplots show that Osmena Park samples appear to be closer to the Cebu samples used as an outgroup comparison. In fact, the Osmena Park samples may be a smaller subset of a greater variability seen at Cebu, though this could in fact be caused by multiple grouping patterns at Cebu that are not being expressed due to the small sample size analyzed here. By grouping these same elements chronologically instead of by site differentiation, later time period groups encompass a wider range of elemental concentrations, suggesting increased access to and variability of production sources. This suggests that over time, and as the Tanjay polity grew in size and socio-political complexity, individuals

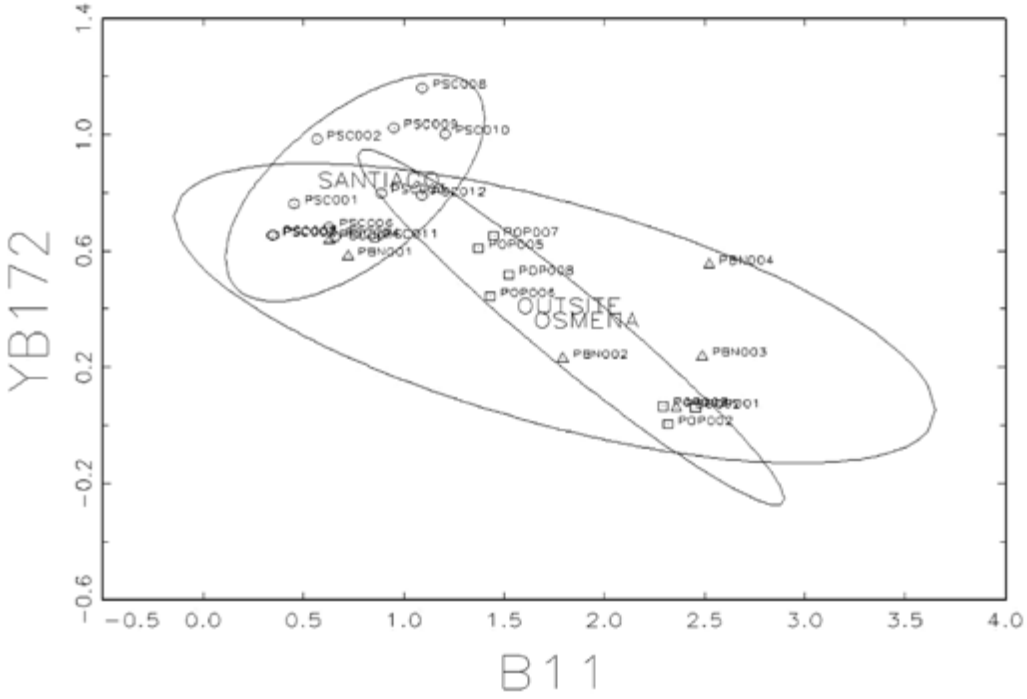


Figure 4. Bivariate plot of element concentrations across porcelain samples. Santiago Church and Osmena Park overlap some but form fairly distinct grouping patterns. Osmena Park groups more strongly or as a possible subset to the out-group seen at Bacsije. Plot by R. Dennison.

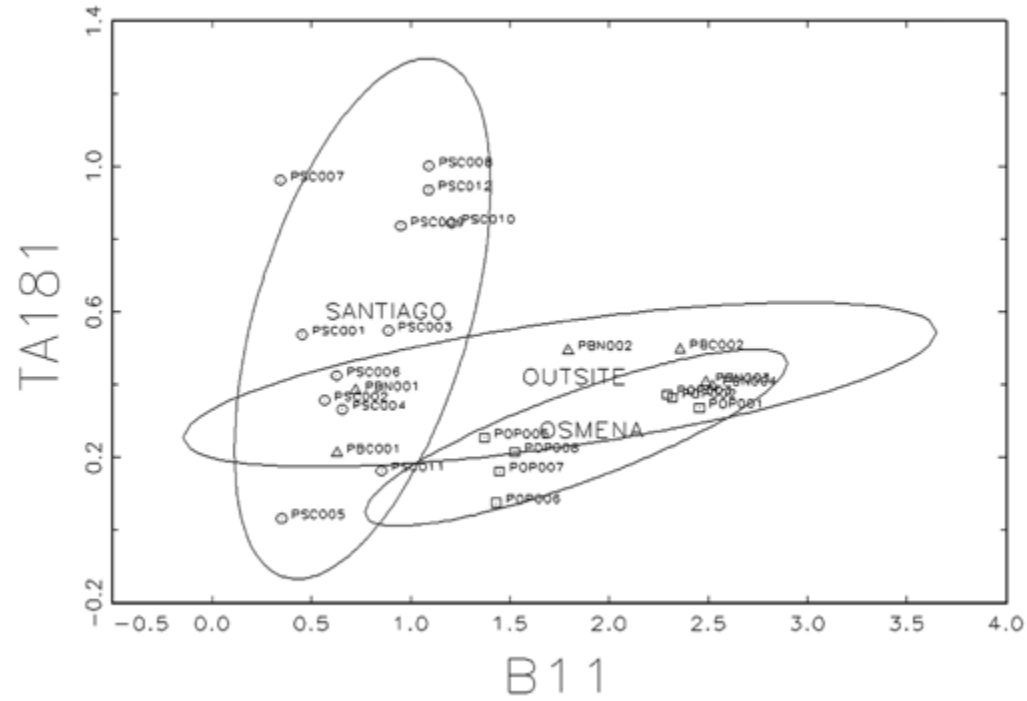


Figure 5. Bivariate plot of elemental concentration across porcelain samples from all three sites. The same grouping patterns can be observed as in Figure 4, with Osmena Park and Santiago Church showing mostly distinct groups, and Osmena park appearing more similar to outside grouping patterns. Plot by R. Dennison.

and groups of varying status and embedded in diverse social networks were able to expand their acquisition strategies to include a wider variety of wares from eclectic sources.

Results from principle component analysis showed that the first three principle components account for 92% of the variability in the sample set. This confirmed which elements were used in grouping patterns seen in the bivariate scatterplots, and by looking at factor loading scores and scatter plots of vectored weighting scores on the principle components it is possible to show which elements most heavily influenced the principle components.

Cluster analysis was performed on the entire dataset. The Santiago Church locale samples clustered into two groups largely based on time period. PSC008-10 and PSC012 formed one group, while PSC001-7 and PSC011 formed the second (Figure 6). The Osmena Park samples also formed two groups separated by time, but were grouped less tightly, showing similarities with samples from the Cebu area. POP001-3 grouped with PBC002, PBN002-3 and, distantly, with PBN004. This was true for the earlier samples at Osmena Park as well, with POP004-8 grouping with PBC001 and PBN001 (Figure 7).

Grouping based on temporal aspects may represent changes at the production end as kiln technology or ceramic processing shifted, but further direct work on the source material itself would be needed to test this. Cluster analysis on early and late samples respectively in Tanjay maintained this group separation between the two sites, showing that the pattern seems to be the same across the two time periods (Figures 7 and 8). The grouping patterns expressed suggest that Osmena Park had a broader

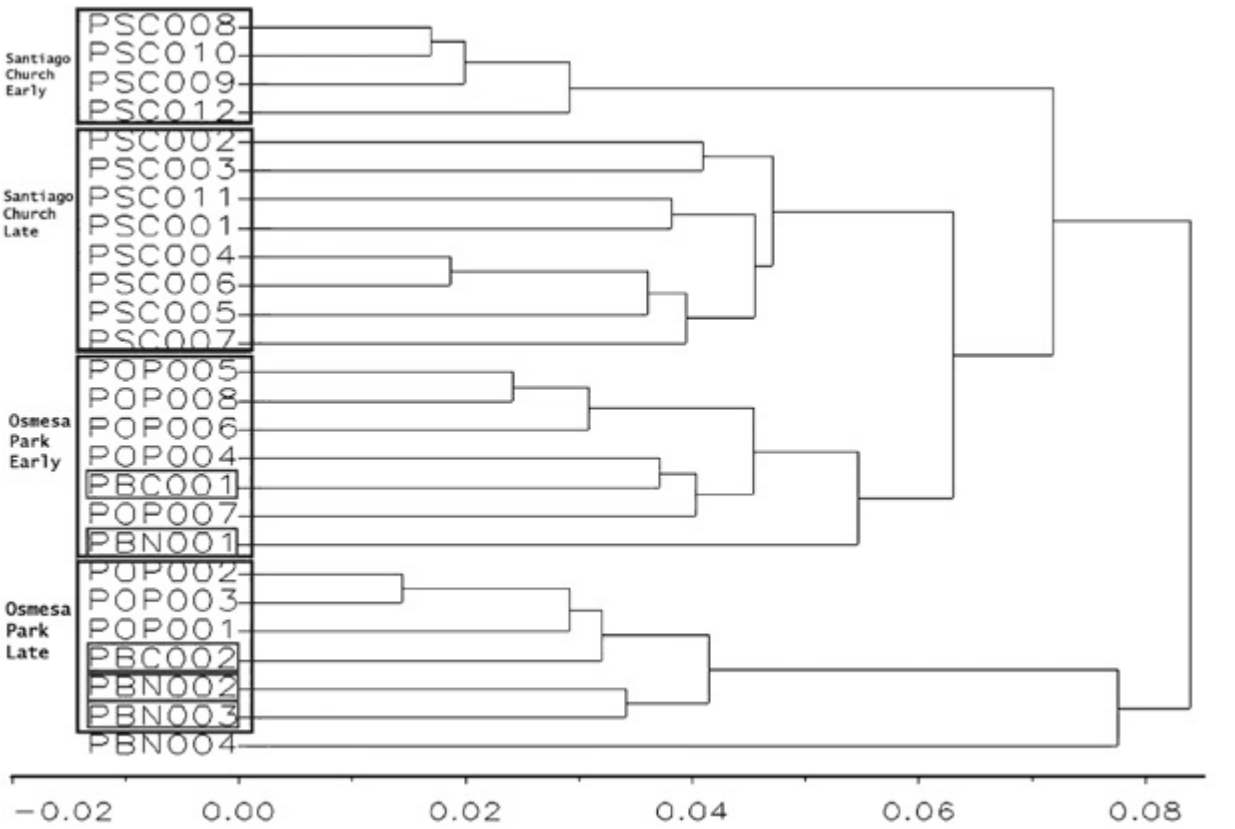


Figure 6. Large cluster analysis of all samples shows four main groups and a possible outlier (PBN004). In general, Santiago Church and Osmena Park grouped separately from each other and additionally grouped into early and late subgroups as labelled. The similarity between Bacsije and Osmena Park can again be observed here, especially in the later period. Plot by R. Dennison.

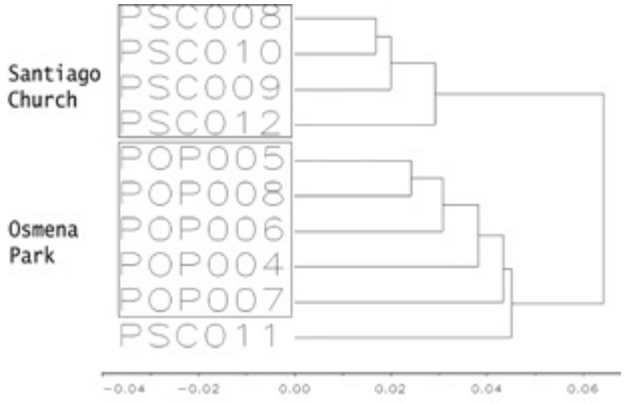


Figure 7. Cluster analysis of earlier period samples from Tanjay alone shows a similar grouping pattern to that observed in Figures 4 and 5, with the possible addition of PSC011 being further from the group then previously seen. Plot by R. Dennison.

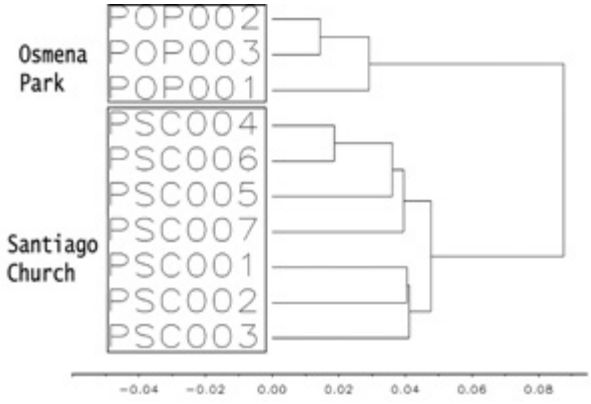


Figure 8. Cluster analysis of later period samples from Tanjay alone again shows a tendency to group by site location in this period. Plot by R. Dennison.

range of sources to draw on from trade than did Santiago Church. Since Santiago Church and Osmena Park represent interpreted different socioeconomic standing, these results are probably an expression of differential access to trade goods. Santiago Church, based on other archaeological evidence, was a higher status residential zone where the chiefly elite resided (Junker 1999: 152-158), so the reduced variability and tighter clustering of porcelain types may represent elites seeking a single high-status product or acquiring objects of status through certain more prestigious and more restrictive channels. In contrast, the inhabitants of Osmena Park may have been more eclectic and somewhat independent in their acquisition strategies, seeking porcelain of lesser quality (such as poorer quality Chinese pieces, and even more poorly executed Southeast Asian wares) through any source they could access (including illicit trade channels), rather than obtaining their porcelain solely through the largesse of elite, who gifted high quality wares to loyal supporters.

There are always dangers in using a small sample set and in presenting preliminary results that can drastically change as further analysis is conducted. As more porcelain samples are added to the database for these two occupation phases and residential zones at Tanjay, a significantly more nuanced look at social access to porcelain, porcelain use contexts, and what these can tell us about changing social dynamics and power relations will be developed, and these preliminary results could be undergo substantial revision.

Conclusions and future work

While this initial analysis of compositional groupings of porcelain focuses primarily on the inhabitants of the a coastal chiefly center between the twelfth and early sixteenth centuries CE, and how they might have negotiated access to these potent material symbols of status and power, this is only one piece of a complex network of social dynamics and power relations visible at multiple scales. Historical and archaeological evidence paints a picture of a large number of maritime trading polities in the Early Historic Period, of varying geographic scale and political complexity, and the polity at Tanjay was a relatively small-scale chiefdom compared to Manila and Cebu (Junker 1999: 113-118). Historic sources indicate that chiefly nobility interacted frequently with one another through elite marriage arrangements, military alliances and ceremonial feasting, activities that often involved the transfer of porcelain as bridewealth or as alliance-sealing and war reparation gifts (*ibid.*: 292-302), and even seized porcelain from distant centers as part of slave-raiding expeditions (*ibid.*: 345).

In analyzing porcelain consumption at Tanjay, we must therefore recognize that the chiefly elite were unlikely to have amassed their porcelain assemblages independently of relationships with powerful chiefly allies elsewhere. The analysis must necessarily expand to include the distant foreign traders and elites at even more powerful Philippine centers like Manila and Cebu to examine the larger inter-regional social dynamics and politically fluid alliances systems involved in this prestige goods exchange in the archipelago. At the same time, small-scale upland swidden farming and foraging groups were inextricably tied to the coastal chiefdoms through their long-term roles as providers of forest products funneled into the maritime trading systems (Junker 1999: 240-246). Their historically-documented use of porcelain obtained from lowland trade partners, materially evident in the Tanjay Region in porcelain fragments at upland sites stretching to more than thirty kilometers from Tanjay (Junker 2002a: 232-234), will allow us to examine not only how lowland elites and traders may have 'filtered' their access to porcelain types, depending on lowland concepts of status-related exclusivity, but also the role porcelain played in materializing social and political relationship in their own societies.

Therefore the next step in this long-term project of chemical typing and sourcing of porcelain is to broaden the geographic scope within the Philippine archipelago in order to examine the larger social arena of both inter-polity competition for porcelain (i.e. varying strategies to undercut trade competitors) and inter-polity porcelain prestige goods exchange for strategic inter-regional alliances (such as elite marriages or forming military coalitions). Porcelain samples from habitation contexts have already been collected and are being analyzed from Santa Ana (within the Manila polity) and Bacsije Carcar (within the Cebu polity), both significantly larger polities than Tanjay and likely showing access to a different array of Chinese kiln products, reflecting more complex forms of social stratification. Comparisons of chemical signatures of porcelains from different ports will also provide some insights into the issue of whether most Philippine polities had direct access to porcelain shipments of varying quality through island-hopping trade by Chinese ships, or relied primarily on internal prestige goods exchanges controlled and filtered by chiefs who received large shipments of porcelain at their more prominent ports (or a combination of these distribution patterns). Secondly, porcelain samples have been selected for chemical analysis at two settlements, the Mendieta and Calumpang sites, approximately eight and eleven kilometers upriver from Tanjay, and representing secondary interior trading centers where one would expect bulk forest products transported by tribal swidden farmers and foragers to be exchanged for porcelain, local earthenware ceramics, metal goods, and textiles.

In addition, direct comparison to kiln sources is necessary to link Chinese production and distribution strategies to acquisition strategies in Philippine societies, as well as to begin to piece together the complex system of linkages in this exchange network. To this end, both clay and porcelain samples have been collected from Chinese kiln sites for chemical analysis to compare kiln clays and kiln products (the latter both typologically and chemically) to porcelain found at this diverse array of Philippine sites. While there have been numerous sourcing studies conducted on Chinese kiln material (e.g. Leung *et al.* 2000: 132-140; Li *et al.* 2005; Wen *et al.* 2007; Zhu *et al.* 2011; Cui *et al.* 2012), the variety of chemical compositional techniques used and the generally isolated nature of these studies has made comparison between sites and kilns difficult. The database is further enhanced by the porcelain samples for chemical analysis from several shipwrecks within the Philippine archipelago recovered by the National Museum of the Philippines, including the Marinduque, San Isidro, Pandanan, Lena Shoal, and Santa Cruz shipwrecks, all dated somewhere between the mid-fifteenth and early sixteenth century CE (Brown 2009: 173-176). Finally, more refined statistical techniques will be utilized on the chemical data and compositional groupings once the sample size is sufficiently large enough to warrant them.

This research highlights the different archaeological contexts in which porcelains are deposited, and thus begins to address issues related to the varying scales of social networks that disseminated porcelain, as well as the diverse forms of social valuation for porcelain in household display, mortuary rites, inter-

group competition, and social integration as these objects crossed social and cultural boundaries. We argue that the diverse strategies and decision making that occurred amongst individuals and groups in the acquisition, distribution, and use of porcelain can only be understood through a multi-scalar approach. This type of approach does not privilege 'top-down' views of porcelain valuation and social meaning from the porcelain producers or even the local elites at the most prominent Philippine ports, but instead recognizes that objects such as foreign exotics lose and shift their meaning as they move in and out of spheres of circulation – from chiefs at coastal centers, to subordinates and allies, and even to interior tribal populations and foragers who use porcelain in culturally-specific ways. That is, material objects have a cultural biography and social history that can only be unraveled by documenting the systems of meaning and differential practices of actors in these chains of exchange (Appadurai 1986; Shennan 1989; Hodder 1992).

This dataset is unique in that it draws upon well-documented habitation contexts for porcelain (such as in trash pits associated with feasting events, and scattered household debris features under raised pilehouse floors), instead of museum showpieces of often unclear derivation, or strictly burial remains representing a small element of porcelain use. The emphasis on whole porcelain vessels and design-based typological studies has also reinforced the tendency to ignore the many small porcelain sherds in better-provenienced museum collections and at archaeological sites as 'non-diagnostic' of kiln origins, periodization, or social valuation. Therefore, much previous work has ironically viewed these porcelain fragments, which are in archaeological settings that might best reveal 'social practice' within local communities, as contributing little as data sources, an approach that can skew our understanding of the social contexts of porcelain use and exchange in local communities. By using chemical analysis and identifying sources from habitation context sherds, not only are the geographic reach and volume of specific kiln products better evaluated, but a more robust model can be created to examine the role of imported porcelain in the political economy and social organization of Island Southeast Asian societies, which in turn drove the demand for Chinese porcelain production and export.

Acknowledgements

LA-ICP-MS lab analysis was conducted at the Elemental Analysis Facility at the Field Museum. We appreciate the assistance of Laure Dussubieux in making the Elemental Analysis Lab available for our work and advising us on compositional analysis. We would like to thank Mark Golitko and Lisa Niziolek for their guidance on LA-ICP-MS analysis. Finally, we gratefully acknowledge the following individuals and organizations that facilitated access to porcelain samples and kiln sites in China and the Philippines, including Tianlong Jiao, Bobby Orillaneda, Xiamen University, and the National Museum of the Philippines. The Henry Luce Foundation generously provided some of the funding that allowed visits to kiln sites in southern China and work with National Museum of the Philippines collections as part of an institutional grant for Southeast Asian Archaeology at the University of Illinois at Chicago. This paper is a revised version of the EurASEAA14 conference presentation originally titled 'Chinese porcelain trade in the Philippines: preliminary chemical analysis'. We are grateful to an anonymous referee for comments and suggestions.

The kilns of Myinkaba – for pottery or glass?

Don Hein and W. Ross H. Ramsay

Monochrome drawn glass beads have been found in numerous Southeast Asian archaeological contexts and represent bead production and trade over millennia. Given the ubiquity of finds, major industrial infrastructure must have existed to meet production demand, but hitherto no Southeast Asian site has revealed the required furnaces and infrastructure. Similar to ceramic kiln sites, material evidence of glass production can be expected to survive over time. Seven furnace constructions at Myinkaba, near Bagan, Myanmar (Burma), previously reported as ceramic kilns, have now been identified as glass furnaces for both the smelting of raw glass from local materials, and the manufacture of glass beads of the Indo-Pacific monochrome drawn type. Chemical analyses of the glasses and glazes demonstrate a continuum in composition from high-sodium low-lead types (17-22 wt% Na_2O) through to high-lead variants (66 wt% PbO) lacking sodium. Output capacity appears to have been large enough to anticipate contribution to domestic and long-distance markets. This paper reports on the infrastructure and operation of the industry, and discusses the possibility that the furnaces of Myinkaba not only produced glass but may have made glazed fittings for use on Buddhist monuments dating from the tenth century CE.

Introduction and description of the excavation findings at Myinkaba

More than twenty of the 2000 surviving religious Buddhist monuments at Bagan in northern Burma have facing glazed bricks or glazed architectural fittings comprising narrative plaques, decorative panels, cornices, and floor tiles (Figures 1-3). For many years the origin of their glazing has been in question (Dello Strologo 1963: 3; Kyaw Nyein 1963: 202; Myo Thant Tyn 2003). Although evidence is lacking, it has been argued that they were probably made at Bagan, as some fittings appear to be structurally integral to the design of the buildings. For example, two of the early period monuments, Ngakywenadaung Stupa and Sintzedi Pagoda, are of this order because facing bricks, some with complex form, would need to be on hand at the time of construction. Many monuments have didactic Buddhist Jataka story plaques and decorative glazed fittings that were made to fit into an architecturally prepared niche. In the case of Mingala Zeidi, the monument was designed for plaques that were never installed (Strachan 1989: 102). Such fittings could have been supplied to design order from a more distant source, although it would have been convenient for production to be local. The question of where the glazed fittings were made was renewed with the discovery fifty years ago of a 'kiln' in the early township of Myinkaba, located about three kilometers south of the walled city of Bagan.

Figure 1. Ngakywenadaung Pagoda, Myanmar. Photo: D. Hein.

Figure 2. Singzedi Pagoda, Myanmar. Photo: D. Hein.

Figure 3. Amanda Temple plaque. Photo: D. Hein.

In 1963 a team led by S. Dello Strologo, a ceramics expert and USAID contractor, and Kyaw Nyein of the Union of Burma Applied Research Institute (UBARI) Ceramics Laboratory, conducted the excavation of that kiln, to determine whether the structure had been used for the production of glazed architectural material. Their brief report, reinforced in a public lecture by Dello Strologo, expressed doubt because the glazes they observed in association with the kiln were not similar in 'color, transparency, quality [or] composition' to the glazes on the temples (Dello Strologo and Kyaw Nyein 1963: 3). While they judged that the kiln was too small to make the quantity of the material needed, they also somewhat ambiguously claimed there 'was ample evidence that it was used for making glazed products' (Dello Strologo 1963: 4). A drawing included with their report showed an updraft 'kiln' with an enclosing dome. This raised our interest because, in our experience, in Southeast Asia such updraft pottery kilns are cylindrical and open-topped. Furthermore, the design as illustrated did not appear to be functional as no stokehole was shown, although a door with precise measurements was (Figure 4).

Summary of excavation results

In 1999 the same structure was re-excavated by an Australian and Burmese team led by Don Hein and Myo Min Kyaw, to verify its shape (Hein 2003: 23), and the observed difference was surprising (Figures 5-7). The revealed form was cylindrical with no hint of doming, and, almost incredibly, there was no evidence of the door shown in the 1963 drawing of Dello Strologo and Kyaw Nyein. It seems that the excavators reasoned if the kiln was domed then a door must have existed to allow loading, and as it was thus necessary to find a door, they misunderstood a small aperture in the wall that in fact existed for an entirely different purpose.

They correctly indicated in the report drawing, but did not describe, that the kiln had an unusual construction of walls made in layers, which on our excavation proved to be of sandy clay containing some small river stones and pottery sherds, manipulated to form each continuous layer about five

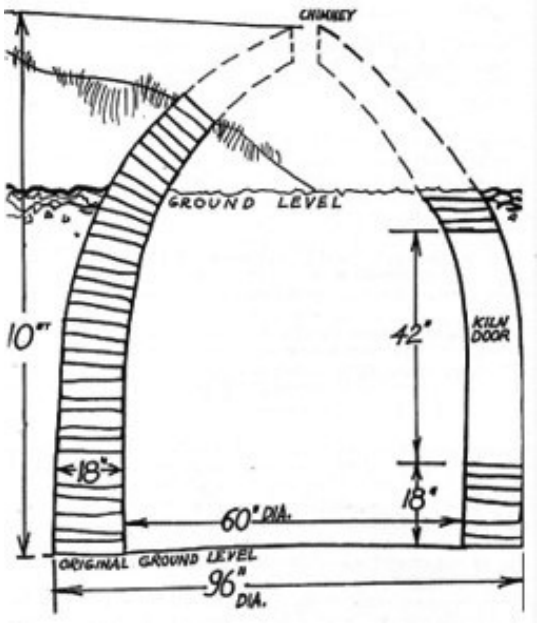


Figure 4. Drawing by Dello Strologo and Kyaw Nyein (1963). Note the angled layers, kiln door, and flat floor.

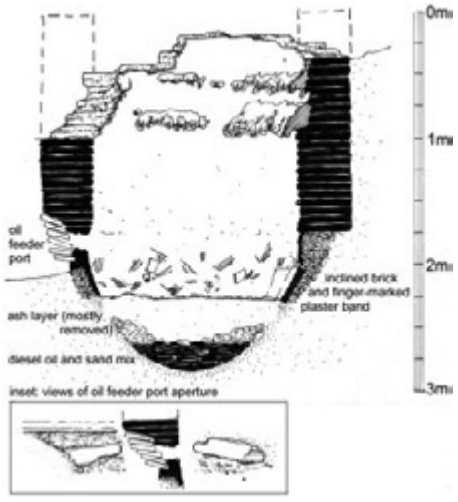


Figure 5. Drawing with inset showing the aperture in three views (outside, sectional, and inside), by D. Hein.

Figure 6. Furnace #1 in 1988. Photo: D. Hein.

Figure 7. Excavation of Furnace #1 in progress in 1999. Photo: D. Hein.

Figure 8. Ash layer of Furnace #1. Photo: D. Hein.

Figure 9. Oil-sand layer of Furnace #1. Photo: D. Hein.

centimeters thick. This kind of construction is uncommon in Southeast Asia, only reported in one other case at Thazin Pan village at the confluence of the Lagumbyee and Htee Ye Pale creeks in Bago Province of Burma (Hein and Barbetti 1988). However, the Dello Strologo-Kyaw Nyein drawing showed a progressive inclination of clay layers to form an enclosing dome wall, but in fact all the layers of the Myinkaba structure were horizontal and formed a vertical wall. Dello Strologo and Kyaw Nyein (1963) described the inner wall of the kiln as being covered with thick green glaze, but in some areas we could see that that had exfoliated, clearly revealing an underlying yellow glaze which they did not mention in their field report (see below; Figure 10). Dello Strologo in his talk listed glaze colors on potsherds found in association with the kiln as being 'clear transparent, to olive green, brown turquoise, green' and stated that 'the glazes were transparent' (*ibid.*: 4). In their report there is no comma after 'brown' and it is not clear whether they meant 'brownish turquoise' or two separate colors. In fact, opaque brown glaze is also found at the site, although only rarely. Nor was black glass as beads included among finds from the first excavation. Despite its ubiquity, yellow glaze was not mentioned in the first report and was only casually included in Dello Strologo's (1963) talk given a few months later.

From our 1999 excavation we observed that the walls of the kiln were very thick (forty centimeters) and that the inside diameter of the round structure was 1.5 meters. The lower inside wall had a hardened matte white surface, common to kiln hot-face areas subjected to burning fuel and ash. Rather than a flat floor as shown in the Dello Strologo-Kyaw Nyein drawing, the bottom of the kiln wall curved inwards to begin a hemispherical shape partly surfaced with clay plaster and brick (Figure 7). Below that point was a layer of fine grey compacted ash about fifteen centimeters thick that had been largely removed in the previous excavation (Figure 8). Dello Strologo and Kyaw Nyein (1963) reported that the ash overlaid charcoal, which they did not disturb, but in our excavation of the portion of the deposit that had been left undisturbed, the 'charcoal' presented as a friable sandy black oily substance in a layer about twenty centimeters thick (Figure 9). Below that layer was natural sand, and *c.* thirty centimeters below that natural rock was reached.

The Dello Strologo-Kyaw Nyein drawing showed no aperture in the wall of the kiln for the admission of fuel,

Figure 10. Internal layering of Furnace #1 wall. Photo: D. Hein.

but our observations showed that a narrow, slightly inclined, irregular-shaped slot forty-seven centimeters wide by thirteen centimeters high did penetrate the wall. The aperture was too small to serve as a stokehole for wood, especially as a number of offset bricks partly blocked the opening. At several points on the inside wall below the aperture, glass had wept out of fissures, appearing as small globules and runs, a condition unknown in glazing kilns. Excavation of undisturbed ground outside the kiln wall opposite the aperture exposed bedded channeling in the sediment, surrounded by reddened sand that extended about fifty centimeters from the kiln wall, a condition that showed the area had been subjected to heating beyond that normally found outside the walls of a kiln, indicating that the area had been subjected to heat from a source outside the kiln (Figures 11-12; Hein 2003: 26). These factors, combined with the dark oily substance found in the bottom of the kiln, suggested oil had been used as fuel, and that at times that fuel had ignited outside the kiln. Later analysis by the Australian Mineral Development Laboratories of the oily substance showed the presence of distillate (AMDEL 2002). From early times, oil from natural surface soakage in the area of Bagan had been used for domestic heating and lighting (Yule 1855: 18) and analysis of samples obtained from commercial oil wells on the banks of the Ayeyarwaddy River at Yenangyaung, eighty kilometers to the south, revealed a similar distillate rating (AMDEL 2004); the oil sample was taken by us directly from the extraction pipe before any processing.

Further finds strongly indicated the structure's purpose. Potsherds of thick-walled earthenware jars about thirty centimeters high, with round cord-marked bases, raised necks and rolled mouthrims were found in the immediate vicinity. Some of the jars had thick accumulations of glass, mostly blue, green, yellow and black in color, on the inside face, the amount often being far too great to be explained as glazing faults. Glazing was not found on the outside of any of the jars. A near-complete jar found during our excavation contained a dry, finely granulated raw mixture of quartz and flux that appeared to be a possible mineral batch ready for melting. Jars of the shape with a round cord-marked bottom (Figure 13) are not a common domestic utensil; although the shape is well documented in Burmese pottery (Aung Thaw 1968: fig. 51), the only similar bottom shape with cord-marking is that associated with thin-walled

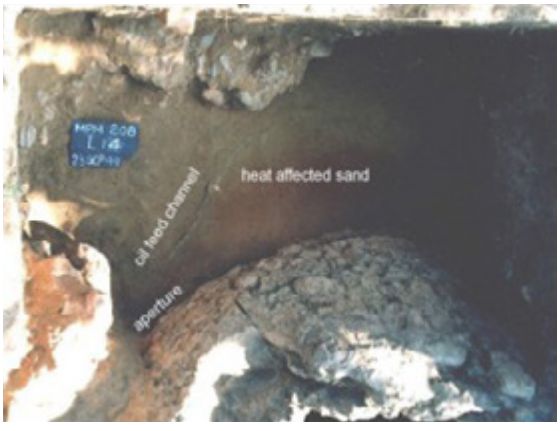


Figure 11. View outside the aperture showing heat-affected sand, and oil feed. Photo: D. Hein.

Figure 12. External oil feed line. Photo: D. Hein.

cooking vessels of a quite different form. Such cord-marking may be a device to facilitate heat transfer (by exposing more surface area).

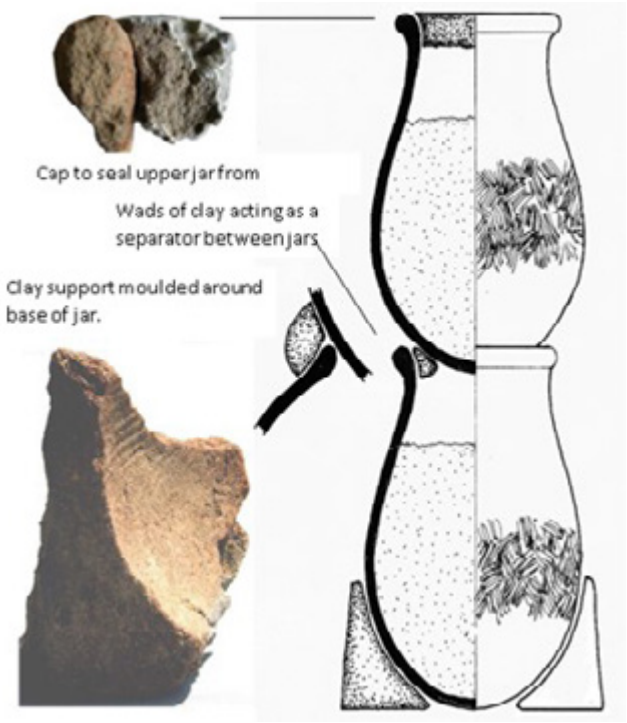


Figure 13. Setting method for smelting jars in Furnace #1. Images by D. Hein.

No evidence of a structural floor was found inside the furnace although a floor must have existed to support the jars. A positive indicator of this was finds of clay shapes that had been molded around the base of the round-bottom jars for support during firing (Figure 13). The base of this support was flat, consistent with being placed on a horizontal floor, and had a texture suggestive of it being in contact with a hard, flat, slightly textured surface. The inner surface of the clay shapes had a curve corresponding to that of the lower part of the jars, and was impressed with a corresponding pattern where the clay had been pressed against the cord-marking on the jars. These pieces provided the support required for the lower jars to be held firmly upright during the smelting process. Other finds from the excavation showed how the jars had been stacked. Either several small clay lumps were placed on the inner face of the jar's mouth to act as separators or, in the case of wider jars, clay lumps were applied on the shoulder of the jar to support the one above. No reason for the difference in jar form was apparent. That jars were set one on another shows that at least two layers of pots were set for firing, possibly more. The mouth of the uppermost jar was sealed with a plug of clay to prevent contamination of the glass.

This kiln (defined as #1; features were numbered in the order of their discovery) was located on rising ground; its upper parts were largely buried in sand that appeared to be post-operational wind-blown drift, because sand against the furnace above the firing port had not been affected (turned red) by heat from the furnace, and therefore was not there at the time of the furnace's operation. That fact and the thickness of the upper walls indicate that above the aperture the furnace was free-standing. It is estimated that the top of the furnace was originally 1.25 meters above ground level, which would have been convenient for top loading, the only possible way the jars could be put into the cylindrical structure. The furnace probably operated at an upper level of about 1000° C, as the jars did not reach stoneware temperature.

Leaving open the question of its possible use as a glazing kiln, it was evident that the structure was employed as a furnace for the smelting of sand and flux to make glass. This oil-fired kiln-furnace is the only one of its kind at Myinkaba and the only historic oil-fired kiln known in Southeast Asia. Although a few glass beads were found in association with the furnace, it is unlikely that it was used as a manufacturing furnace, as it would have been inconvenient for artisans to work around the edge of such a large open structure due to the heat. Also, the firing chamber was too tall for glass-making operations because the external wall was inconveniently high above ground level, and the internal distance from the top of the wall to the position of (what would need to be) a single layer of pots resting on the firing chamber floor.

Figure 14. Excavation site of Furnace #7 on boundary of Abeyadana Temple. Photo: D. Hein.

Figure 15. Excavation of Furnace #7 by Myanmar Department of Archaeology. Photo: D. Hein.

In 2003 another furnace (#7) was found near Abeyadana Temple, but at the time only limited excavation inside the structure was possible (Figures 14-17). Department of Archaeology staff (Myo Thant Tyn, Aung Bo, Nyein Lwin and Soe Win Htay) dug the furnace to a depth of about eighty centimeters, then later D. Hein continued the excavation to floor level (Myo Thant Tyn 2003: 30).

Figure 16. Excavation of Furnace #7 by D. Hein. Photo: D. Hein.

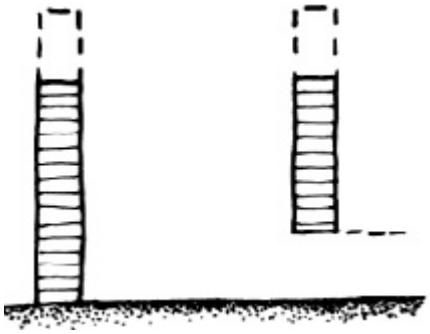


Figure 17. Elevation sketch of furnace #7, by D. Hein.

Characteristics included the same shape, size and layered clay construction as #1, except that the thickness of the layers was less regular. The inner walls were glazed with prominent drips and runs at the lower levels, and a layer of ash and charcoal was concentrated near a stokehole, which was of a size that indicated wood firing. The structure had a flat base of natural ground. Finds included glass beads and wasters, mostly black and yellow, but also green and blue, some round-bottom jar sherds with glass on the inside, and a large amount of fallen kiln wall. Unlike furnace #1, which from the aperture down had been partly set into the ground, furnace #7 appeared to be built on the contemporary ground surface which was more than a meter below present ground level. No evidence of a separate floor was found. As with #1, a floor was essential to support glass-containing jars and position them above the fire, and perforations in the floor served to spread the heat evenly throughout the furnace. Finds from the initial excavation by the Department of Archaeology included a jar filled with light green glass (unfortunately accidentally broken while in storage). The purpose of furnace #7 was probably the same as that of #1, but as no external excavation was done it could not be determined whether smelting jar sherds or support debris existed in the environs of the furnace.

Five other wood-fired furnaces (#2-6) were distributed within a 1000 x 200 meter strip between the Ayeyawaddy River and a parallel line of Buddhist monuments (Figure 18). Like the two larger furnaces they were round, but smaller and with a different form. All were about the same size and three had walls constructed of clay layers in the same manner as the larger furnaces, the exceptions being #5, which had inner and outer walls of brick in-filled with rubble, and #6, which had been dug into the ground. All had fireboxes consistent with the use of wood as fuel. Four were built on the ground surface, but

the surface had aggraded between that time and the present; all were below the surrounding present-day ground level, such that their fireholes and exhaust vents were buried. One furnace (#6) had been dug into the slope of a hill with the inner surface constructed of brick, at least some of which was of individual bricks angled to create the curve.

These furnaces each had a beehive-shaped inner chamber leading upward to a circular opening about sixty centimeters in diameter at the top of the furnace. Except for #6, the walls were thick, widening internally toward the top (due to the beehive shape of the chamber) to form a flat wide top surface. Their height was about ninety centimeters above the original ground level, making it possible for workers to stand around the perimeter.

These five smaller furnaces had two basic forms. Three (#2, 3 and 5) had a small exhaust vent (acting as a chimney) located opposite the stokehole but at a slightly higher level, and had clay flanges (skirts) extending from the firebox and vent, apparently to shield the fire or draft from the wind. Their flat top served as a working surface, a purpose clearly demonstrated by patches of glass deposit. When at operational temperature, some of that glass ran through fissures in the top surface and wept out on the inside surface, forming runs and drips, conditions impossible in a pottery kiln. Furnaces #2 and 3 had circular blind holes *c*. ten centimeters in diameter and of varying depths from ten to forty-five centimeters in the top surface, the use of which could not be determined but which may have served some manufacturing purpose; one idea was that the holes were to support a roof over the furnace (Aung Kyaing 1999: 6). Some of the holes near the outer face of these furnaces were part-circular, raising the question of whether an outer wall had once existed for which no other evidence remained. For the purposes of classification those three structures were termed 'manufacturing furnaces'.

The other two small furnaces, #4 and 6, were horseshoe shaped and had a slightly larger firing chamber and stokehole (Figure 19). Furnace #4 was built on level ground and, in common with the other small furnaces, it would have been possible to work around it. There was no excess of glass on the kiln and

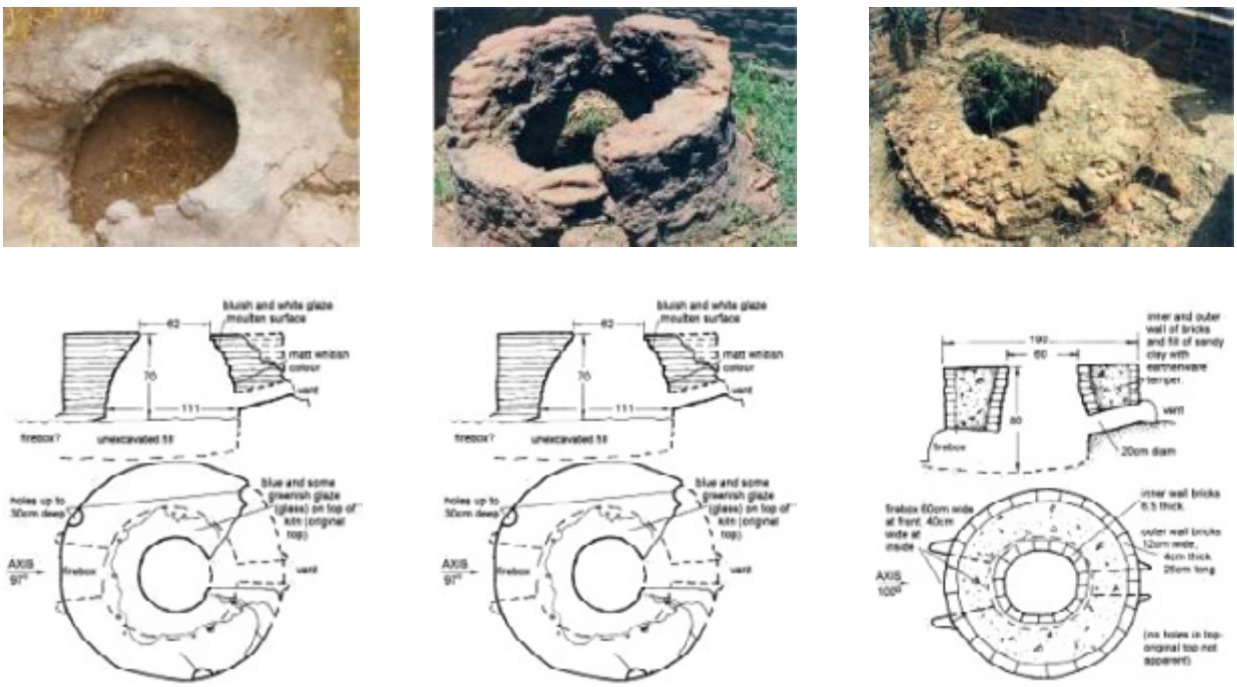


Figure 18. Furnaces #2 (left), #3 (center) and #4 (right). Images by D. Hein.

there was no evidence of an exhaust vent, either because none existed (as the furnace height might indicate) or an upper part of the furnace was missing. Unlike the other furnaces, #6 had been dug into the side of a steep hill with the firebox facing downslope; its exit flue was positioned high in the wall and curved upward to exit at ground level. Like furnace #1, it was heavily coated with green glass on its upper surfaces and on the top of the wall, to a thickness of several centimeters. That the furnace was not used for manufacture was evident from the inability of workers to stand around the structure other than inconveniently in front of the firebox.

Interpretation of the Myinkaba furnaces

The eccentric design of furnaces #4 and 6 suggests they had a different purpose, perhaps for smelting glass, a notion supported by their larger stokehole and chamber that would have allowed greater heat generation. That very few beads were found in association with these two furnaces contrasts with the large number of beads and amount of production debris found around the manufacturing furnaces. The whole area had been subject to extensive disturbance from digging by looters sluicing the ground in the search for gold (witnessed by D. Hein in 1981), a process that left a surface landscape of mounded spoil. However, finds of beads and production debris are likely to represent the approximate place of manufacture. Local people reported that in the past as a side product of their gold sluicing they collected huge numbers of beads for sale. However, the possibility of furnace #4 being dually used to smelt glass and manufacture beads cannot yet be discounted.

Collectively, the seven furnaces constituted part of a glass bead-making industry. The method employed to reduce raw material to glass could not be determined. The most common technique used in the Middle East was first to produce a frit at about 900° C, in which primary fusion of the lower order fluxes took place. In this process, soluble elements would be converted into insoluble compounds. After crushing and washing to remove impurities, and adding colorants, the mixture was reheated to about 1,000° C to make glass ready for manufacture (Newton and Davison 1989: 61). In the absence of any sign of a two-stage smelting process at Myinkaba, and assuming high quality glass was not required for bead making, a one-step process was probably used.

Presumably, the pots of processed colored glass from the large smelting furnace (#1) and perhaps #7, 4 and 6, were distributed to the manufacturing furnaces (#2, 3 and 5), and when required were placed inside on the floor of the fire chamber, presumably with some kind of support for which no evidence was found. The size of the firing chamber of the manufacturing furnaces suggests that three jars could have been contained within the chamber. Heat from the fire would re-melt the glass in the pots, with the draft passing out through the exit vent, the upper opening having been closed, perhaps with a clay slab, although no evidence for this was found. The process of drawing glass from the jars resulted in heavy encrustations of glass around the rims, and it is in the area of these furnaces that most of those jar fragments were found (Figure 20).

Based on the shape of the furnaces and associated finds, it is proposed that the following method was used to produce the beads. First, the lid closing the top opening would be removed and several bead makers standing around each furnace would draw lumps of molten glass from the jars, probably using an iron mandrel (Figure 21). An indentation was then pushed into the lump, and, using pliers, the glass was drawn into a long tube to the diameter required; while still soft it was cut into bead-size pieces. Those pieces were then annealed to round edges to form the oblate shape of the beads, the only bead form found at the site. No annealed tube beads were found, and pieces of tube in the debris appeared to be production waste. This method is in contrast to the Lada process used from the second century BC-AD 1200 in southern India described by Francis (1991b; 2002), in which a large amount (about fifty

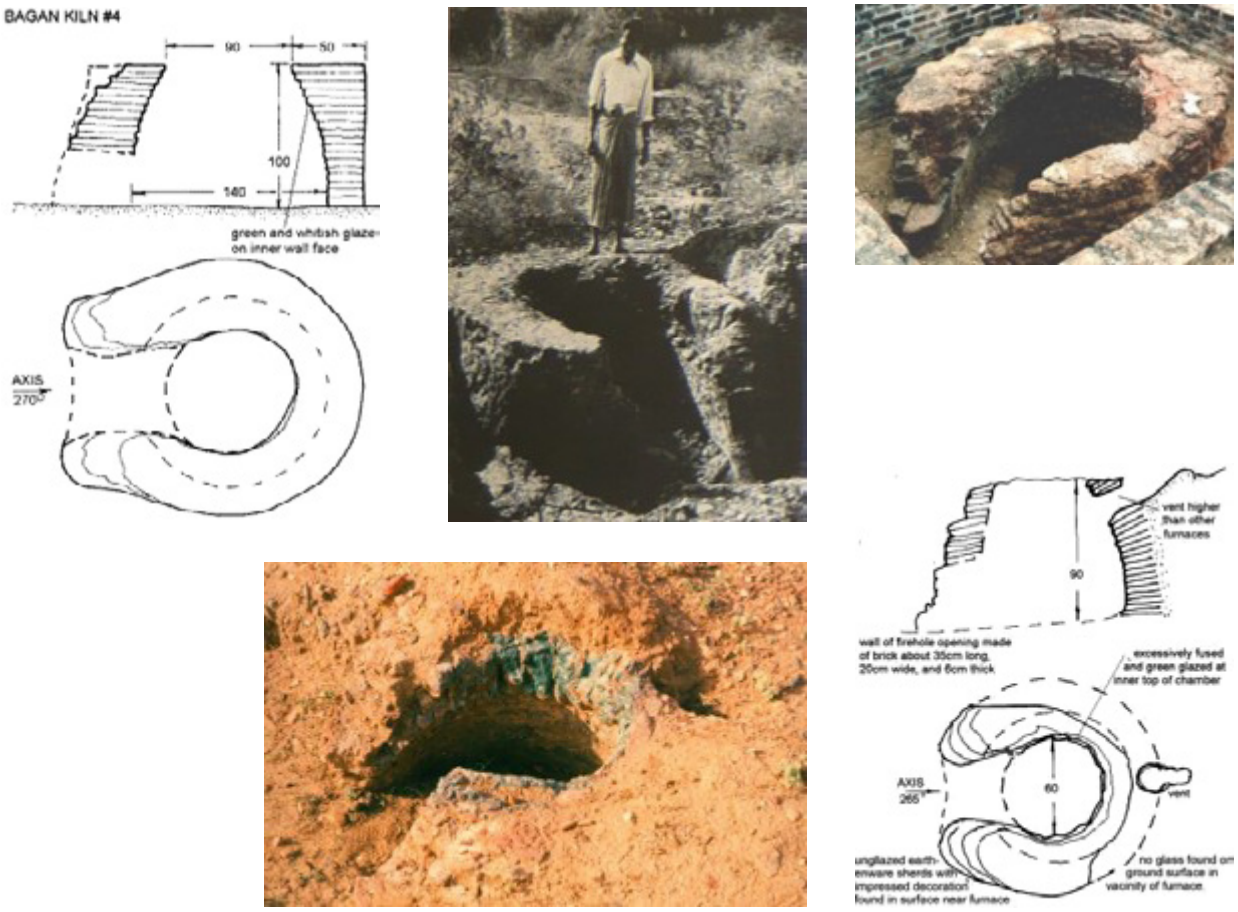


Figure 19. Furnaces #4 (upper) and #6 (lower). Images by D. Hein. Upper center photograph of Furnace #4 after discovery c. 1970 courtesy of UNESCO (Pichard 1993).

kilograms) of glass was formed into a cone while being heated within a domed furnace, from which a tube of glass was continually drawn through an aperture.

The many hundreds of beads found in association with the furnaces were all of a small size, measuring one to six millimeters, with an average *c*. four millimeters (Hein 2003: 46). Translucent green and blue were found in the greatest numbers, with some of pearl white; of the opaque colors, a high proportion was yellow, less was black, and only a few beads were brown. In the same context as the beads were many remnants that demonstrated the manufacturing process, including tubes of glass, pieces with pincer marks from being held during the drawing process, broken and distorted beads, lumps of pigment, jar sherds with a thickness of glass attached around the mouthrim, and larger pieces of glass that appeared to be the result of broken container jars (Figure 20).

Some pieces of thin, curved and flat, black and green glass found in the environs of the furnaces were not consistent with bead-making, being like the remnants of small containers, but these finds were few. Such objects were usually made by blowing a balloon of molten glass with a pipe, fixing it to pontil rod for forming, etc. Such processes were not used for bead making. This matter requires further investigation.

Working periods were probably intermittent, perhaps limited to daylight, which, unless the fire was maintained overnight, would have required time-consuming remelting of the glass mass. Although Cayron (2006: 11), referring to Francis (1991a, 1991b), says that work in India was done at night to avoid

Figure 20. Bead and wasters from Furnace #5 (left); top of broken jar with glass adhered on inside rim, with piece of glass mass (right). Photos: D. Hein.

daytime heat, the relative smallness of the jars and therefore the reduced remelting time might suggest daytime production at Myinkaba. During any break in production, a lid would probably have been used to close the upper opening to reduce heat loss.

All the furnaces but one used wood as fuel, but as Bagan exists now in a dry, desolate environment with little vegetation (Strachan 1989: 7-8) the supply of timber probably was a major problem that increased over time. The location of the furnaces close to the Ayeyarwaddy River was probably chosen to facilitate access to water transportation of both fuel inwards and the outward distribution of manufactured goods. The making of beads could be managed by a number of independent production units, and the distribution of individual furnaces over a large area could suggest family-based operation with a lack of central management. However, the interdependence of the smelting and manufacturing, and commercial realities including fuel supply, indicate a managed industry.

There may be another explanation concerning the wide distribution of the furnaces. Five are clustered between the Nanpaya and Abayadana Temples in the center of Myinkaba (Figure 22), close to monuments, and in most cases appear to be at a lower stratigraphic level. This was indicated by the observations of Aung Kyaing (1999: 6) who states in respect of furnace #2 that people had been 'crossing on it forever' before the excavations and before protective walls were installed. This condition is visually indicated by the photograph of furnace #4 published by Pichard (1993: 302) (see Figure 19). The lower stratigraphic level of some of the furnaces implies that they may predate the nearby monuments. A further point of sequence is the location of the furnaces. For example, smelting furnace #7 is not only at a lower level than the stratigraphy of Abeyadana Temple, but is also located on the line of the boundary wall and within a few meters of the monument itself and an adjacent road. If the temple had existed before the furnace it is doubtful that approval would be given to allow the furnace to be built so close to such an important structure or so close to the road. It seems more likely that when temples were to be established in locations occupied by furnaces, the furnaces were obliged to move, not only due to their position but because of their pollution. In this respect, the smelting furnaces were probably more objectionable, resulting in their replacement with the two more outlying furnaces (#1 replacing #7; #6 replacing #4, which was close to Laytharkyang Monastery). Also, if the building of #1 as a large smelting furnace came relatively later in the sequence it might be assumed that it occurred at a time when the scarcity of wood was acute, thereby encouraging the change to plentiful oil as a fuel, itself a major technological change. Whereas

Figure 21. Conceptual sketch of the bead-making process.

smelting furnace #6 is close to the river, #1 is relatively far inland, probably because oil was easier to carry, but also perhaps because part of its output was not meant for shipment but for entirely local use. The eccentric construction of furnace #5 may also indicate later development.

Based on the particular form of furnaces #2-5, material found in association, and the fact that the chambers of those furnaces were too small and ill-shaped to be useful for the firing of glazed pottery or architectural fittings, the foregoing discussion asserts that those furnaces were used solely for glass bead production. For example, many of the rectangular panels on Somingyi Pagoda were simply too large to fit into any of the manufacturing furnaces. However, the full role of the larger structures, #1 and 7, is less certain, which leads to a very unusual possibility. While finds at the site show that furnace #1, and perhaps 7, made the glass needed by the manufacturing furnaces, they may also have been used as kilns to fire some of the glazed architectural fittings found on Bagan's monuments. Aung Kyaing (1999: 7) believes the furnaces were kilns that may have been used for the glaze firing of 'pots, tiles, and panels for the decoration of the pagodas'. While this would have been impractical in the case of the smaller furnaces, it could be true for #1 and #7.

Referring to furnace #1, the only kiln he knew, Dello Strologo (1963: 4) stated that 'it might produce enough plaques for one pagoda if it was fired repeatedly for one year'. Yet at 1.5 meters diameter the kiln was large enough to contain two or more layers amounting to about one hundred glazed architectural pieces set on their edges, this vertical firing position being indicated by glaze runs on many of the tiles on monuments (e.g. Figure 3). A further consideration is that of production continuity. The monuments of Bagan with glazed bricks, fittings and plaques were built over a period of several hundred years, often some time apart, predominantly between the tenth to thirteenth centuries AD (Pichard 1993), and although the monuments themselves may have taken many years to complete, the making of the glazed fittings could have been completed relatively quickly. The monuments have a chronological scatter that suggests there were periods when there was no demand for glazed architectural fittings (Table 1). Unless those producing such products had orders from afar, at times they must have been out of work. It seems quite logical that the glass and glazing industries, using similar knowledge and skills, might have co-existed to engage the one workforce in either trade. At times the two large furnaces could have changed their role to glassmaking or glazing depending on demand. That the glaze and glass compositions are so similar, especially in the case of the color yellow, enhances this proposition. The raw materials for glass would be melted in a jar to make glass, while the same formula finely ground and mixed with water (and perhaps some clay) would serve as a glaze.

The speculation of a dual industry is merited by technical feasibility. It was certainly possible to fire glazed architectural fittings in furnaces #1 and 7, but impractical for large quantities of glazed bricks. Although bead production at Myinkaba is certain, there is no written history of either glass or glazing at that place, but as Aung Kyaing (1999, personal communication) pointed out, 'hman' in Burmese means glass or mirror (reflective) and there are two areas at Bagan known as 'Hman-kyo', a name that indicates a place of manufacture.

Opaque glaze was used for architecture as it better served the purpose than a translucent glaze of allowing the color to be seen at a distance (rather than as a reflected glare). The plaques, decorative units, and roof and wall tiles on the temples of Bagan were glazed in opaque off-white, green, and yellow. Ngakywenadaung Stupa was entirely faced with green glazed bricks (Di Crocco 1990a), while the compound shaped bricks of Sint-zedi Pagoda had off-white glaze, often with red blemish due to iron in the red bricks bleeding into the glaze. In some cases, the glaze was successfully applied to carved sandstone fittings, a process not reported elsewhere. Di Crocco (*ibid.*) reports three glazes (turquoise, mustard green, and white), but variation in color was probably due to inconsistency in preparing glaze formula

or degradation over time rather than a deliberate attempt to create different colors. Likewise, red is not found as a glaze color, but clay body iron bleeding into white glaze during firing, or clear glaze over red clay can both give the false impression of red glaze.

Blue, black and brown glazes were not used for architectural purposes and are only found as glass. Except for yellow and brown, most of the beads were made of translucent glass, including black which, despite a dense appearance, retains some translucency. None of the green beads is opaque, although architectural fittings only employ matte green glaze, meaning a different formula was employed. Oddly, this was not the case for yellow, which is opaque in both uses.

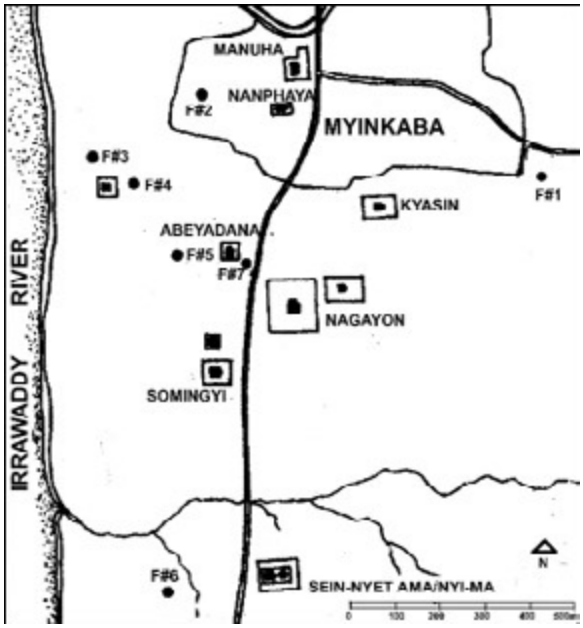


Figure 22. Map of Myinkaba furnaces, Bagan. Map by D. Hein.

Dello Strologo (1963) said that he analyzed the glaze of fifteen samples, but unfortunately did not identify what those samples were, i.e. whether they were architectural fittings, glaze on potsherds found near furnace #1, or from the furnace itself (he did not mention beads at all). He classified the results into two groups: lead-based glazes and alkaline (potassium or sodium) glazes. Kyaw Nyein (1963: 202) said that the composition of the glazes for temple fittings was 'based on lead', which implies the tested samples from other sources that had alkaline analyses may have been associated with the glass furnaces. Preliminary chemical analyses by us question some of these claims. Our limited analyses on glass beads, glass tubes, glass masses in crucibles, and glazes on architectural fittings demonstrate a continuum in composition from soda-low-lead types (17-22 wt% Na_2O) through to high-lead variants (66 wt% PbO) lacking sodium (Tables 2 and 3). These first results lead us to the conclusion that both primary glass production and glazing of fittings was being carried out at Bagan. However, we note that the range in compositions of both glass and glazes does vary considerably, thus making comparison with analyses from other sites difficult.

Chemical compositions of Bagan glazes and glasses

This chemical study of glazes, glass beads and tubes, and associated ceramic architectural fittings demonstrates that the Bagan artisans from central Burma were producing a variety of colored glasses and glazes ranging in composition from high-sodium, low-lead types, through various intermediaries, to a high-lead, sodium-free type. The co-existence of yellow glazes found on ceramic bodies (particularly architectural fittings) having a similar chemistry to yellow glass tubes, suggests that these artisans were applying their glass technology to the colored decoration of architectural features as well as glass beads. Moreover, the evidence for high-lead glass manufacture on site indicates the production of high-lead glass items some 500 years before such a recipe was developed in the Western world.

Nine samples of ceramic bodies, associated glazes, glass, and a blue pigmented clay were subject to chemical analysis using a scanning electron microscope with an energy dispersive attachment. Sample preparation involved polishing minute samples, mounting in epoxy resin, carbon coating, and analyzing in the School of Engineering, Monash University, Melbourne. Operating conditions are given in the appendix attached to this article.

Table 1. Bagan monuments with glazed treatments in approximate construction sequence (after Kyaw Nyein 1963; Strachan 1989; Pichard 1993; Aung Kyaing 1999).

Various spellings of the names of monuments are used; where possible Pichard's spellings are used here. The new monument number is shown first followed by the old. Authors express the foundation dates of monuments in different terms; again, Pichard's are listed first. To give more defined dates, Strachan cites dedication inscriptions, the dates of known builders, and one monument's association with another. Some glazed fittings on late monuments are thought to have been re-used from earlier monuments. The monuments with an asterisk are based on information in Aung Kyaing 1999 and their glazed elements have not been seen by the authors. L/P – late period, U/L- unlisted.

Name	Mon. No.	Date CE	Type
Ngakywenadaung	1603/911	C11/C9	Green facing plain bricks
Naga-yon-hpaya	1192/530	C11/1087	Green fittings and floor tiles
Shwe-hsan-daw	1568/880	C11/1070	First glazed Jataka plaques sealed within
Sint-zedi	377/230	C12/UL	Glazed facing bricks
Shwezigon	1/1059	C12/1102	Stone and clay plaques on three terraces
So-min-gyi-hpaya	1145/491	C12/1204	Unique modeled floral/animal design
Ananda-gu-hpaya-gyi	2171/1465	C12/1105	1472 plaques on four terraces
Hti-lo-min-lo	1812/1110	C13/1211	Extensive mono- and multi-color fittings
Shwe-gu-gyi	1589/901a	C12/1131	Floral green tiles, squares, corner pieces
Sula-mani-gu-hpaya	748/364a	C12/1183	Rectangular, square, round, most in relief
Dhammayazika	947/412a	C12/1196	Plaques on three levels, diamond cen. tiles
Ya-da-na-zedi-hsin-pya-gy	1478/791	C12/LP	Plaques, round top and rect., diamond insert
Gawdaw-palin*	1622/930a	C12/UL	Unknown
Encased Pagoda*	1469/782	C12/UL	Unknown
Ratana-gara*	1656/960	C12/UL	Multiple colored glazed elements (destroyed)
Pha-gu	1610/918	C12/UL	Rectangular green tiles plastered to appear square
Mingala-zedi	1439/752	C13/1277	Plaques on four terraces, small pagoda decorated tiles
Tayok-pyi-hpaya-gyi	539/295a	C13/1280	Green and yellow tiles with geometric insets
Man-aung-hpaya	1479/792	C13/ UL	Green tiles, dancing figures, diamond in rect.
Sint-quet-zedi	397/240	C13/UL	Square, lotus, round top, floor tiles
Monument	1756/1058	C13/UL	Leaf-shaped, square, quarter round top tiles
Taung-ta-wet-gu-hpaya	843/386	C13/UL	Green and yellow glazed fittings on terraces
Gu-yo-gyo-hpaya*	1599/907	C13/UL	Unknown
Hput-gu*	1609/917	C13/UL	Unknown
Hman-hpaya	1268/603	C15/UL	High fired green rectangular and lotus tiles
Hman Si Zedi	889/396a	C17/UL	Green diamond and triangular plain tiles
Tha-ye-kyin-hpaya	1617/925	C17/UL	Elements on second terrace
Monument	1921/1218	C18/UL	One row green rectangular tiles

Ceramic bodies

The two ceramic bodies (terracotta?) analyzed (T2 and T3) are characterized by Al_2O_3 levels of 28.2 and 21.7 wt% respectively. Both samples appear to have been made from a sedimentary iron-rich clay which, because of its impurities, contained its own fluxes in the form of K (assumed to have come from sericite), Na, Mg, and Ca. Iron contents in both are very high (T2: 5.6 wt% FeO; T3: 8.3 wt% FeO – Table 2) Sedimentary or secondary clays are typically associated with high levels of TiO_2, FeO, and often MnO (Ramsay and Ramsay 2007) as shown in Table 2. T2, a green glazed roof tile, is associated with a green

moderate-Pb, Na-free glaze, and T3, also a green glazed decorative fitting, has a high-Pb, Na-free glaze (Table 3). The T2 glaze has high Al_2O_3 (9.6 wt%), whilst the T3 glaze has low Al_2O_3 (0.2 wt%).

Glazes and glasses

The glazes and glass beads/tubes fall into four distinct groups: a high-Na, low-Pb composition (T1, T5, T6), a moderate-Pb, Na-free composition (T2), a high-Pb, Na-free composition (T3, T4), and a high-Pb, moderate-Na composition (T9, T10) (Table 2). The colors of these glasses and glazes range from pale green (T1), distinct green to opaque green (T2, T3, T4), distinct vivid (copper sulphate) blue (T5, T6), and opaque mustard yellow (T9, T10). Both glazes and glasses contain variable levels of Cu and Sn, with very high levels of Sn as SnO_2 found in T2 (5.8 wt%), T3 (9.7 wt%), T4 (3.5 wt%), T9 (3.8 wt % average), and T10 (4.2 wt%). T6 is Sn-free.

Francis (1990) reports that iron, we assume as Fe++, imparts a 'bottle green' color to raw glass, whilst the use of copper with iron in the right proportions can provide a range of colors. Cobalt in very small amounts of 0.025 wt% CoO (below the level of detection in this set of analyses) can produce a blue color. T1, T2, T3, T4 vary from light to opaque green,T5 and T6 are opaque blue, and T9 and T10 are opaque mustard yellow. The blue pigmented clay sample (T7) with 22.4 wt% Al_2O_3 is assumed to owe its color to small amounts of cupric ion as hydrated copper sulphate, judging by the presence of 1.2 wt% sulfur as SO_2 (Table 2).

Chemical linkages can be established between yellow glass tubes and yellow glazed ceramic architectural fittings (Table 3). Both glass and glaze are of the high-Pb, moderate-Na type, with distinct levels of Sn. From this we conclude that at least with the production of yellow glass tubes and beads, and by inference other colors, the Bagan artisans were adapting their glass technology to include decoration on architectural fittings such as roofing tiles and facing slabs.

Glass beads in the Southeast Asian context

A major problem in the study of Southeast Asian glass beads, in the absence of associated furnace structures, relates to which bead occurrences are of indigenous origin and which are exotic, derived through trade from China or India. Alternatively, many of the beads may reflect trade with the West, including by means of reworked scrap glass (Francis 1990). More recently, the discovery of glass beads in various parts of Southeast Asia coupled with compositional studies (Moore and Aung Myint 1993; Lankton and Dussubieux 2006, 2013; Carter 2010; Ramli *et al.* 2011) suggests that there were multiple glass bead production centers in both South and Southeast Asia dating back to the Iron Age (Carter 2010). Apparently both China and India developed glass-making techniques independently, with one established site being Arikamedu on the east coast of India dating, back to 250 BC (Ramli *et al.* 2011) (Figure 23).

Possible Southeast Asian glass-making sites are Óc Eo , Vietnam (Francis 1988, 1990, 1991a and b, 2002) and Sungai Mas, Malaysia (Ramli *et al.* 2011). Carter (2010) reports on six Iron Age sites (500 BC-AD 500) from Cambodia but no unequivocal evidence for on-site glass production has yet been uncovered. Analyses of glass beads from Arikamedu, Óc Eo and Sungai Mas indicate that the glass found at all three sites was of an alkali-low-Pb type with low to high Al. In contrast, beads from Cambodia are dominated by various potassic variants (K-Ca-Al, K-Al-low-Ca, and K-Ca-low-Al) and a sodic type (Na-high-Al) (Carter 2010). Minor quantities of a sodic glass with variable levels of Ca and Al have also been reported by Carter. Apparently lead glass is rare at sites in Southeast Asia, with small numbers of lead-bearing beads recovered, including from Angkor Borei (Cambodia), Ban Non Wat (Thailand), and one yellow

lead bead from Prohear (Cambodia) (Carter 2010). These lead beads are regarded as of Chinese origin (Lankton and Dussubieux 2006).

A feature of the analyzed glasses from Bagan, bearing in mind the limited number of analyses presented here, is the absence of high-K glass and glazes from this location. Instead the glasses produced comprise two end members compositions, these being a high-Na, low-Pb, and a high-Pb, Na-free type. Previous work from Southeast Asia demonstrates that high-Na glass beads dominate through the region (Dussubieux *et al.* 2008, 2010). Lankton and Dussubieux (2013) have noted a regional shift from the production of earlier K-bearing glass to Na-bearing types, and this transition is dated by them to around the turn of the millennium BC-AD.

Table 2. Chemistry of Burmese Bagan ceramic bodies, glasses, and glazes.

	T1 glass	T2 body	T2 glaze	T3 body	T3 glaze	T4 glaze	T5 glass	T6 glass	T7	T9 glass	T9A glass	Average	T10 glaze
SiO2	66.56	60.1	51.48	56.45	21.64	27.33	57.09	69.01	66.08	33.75	36.56	35.15	36.77
TiO2	0.34	1.43	0.73	0.76	0	0	0.57	0.27	0.7	0.32	0.4	0.36	0.24
Al2O3	4.81	28.17	9.58	21.73	0.23	0.15	5.52	5.79	22.42	4.14	3.36	3.75	3.37
MgO	0.62	0.63	1.71	3.74	0	0	1.03	0.68	1.45	0.64	0.32	0.48	0.32
FeO	0.98	5.6	1.15	8.31	0.59	0.23	2.97	1.23	1.3	1.68	2.21	1.95	1.32
CaO	1.62	0.06	9.92	2.01	0.39	0.71	1.93	1.75	2.14	0.93	0.98	0.96	1.06
K2O	0.84	2.23	1.15	2.14	0	0.04	1.47	1.91	1.66	0.7	0.68	0.69	0.36
Na2O	18.23	0.16	0	2.51	0	0	22.49	16.85	0	10.68	6.24	8.46	7.56
P2O5	0.52	0.48	0.77	0.81	0	0	0.52	0.87	0.64	0	0.3	0.15	0.02
PbO	3.24	0	15.39	0.75	65.97	65.88	0.35	0.14	0.21	40.73	46.89	43.81	44.45
CuO	1.42	0.41	1.94	0.45	0.88	1.6	5.6	1.41	0.77	0.43	0.53	0.48	0.3
SnO2	0.51	0.63	5.84	0.32	9.69	3.53	0.12	0	1.58	6.06	1.59	3.83	4.23
SO2	0.37	0.15	0.38	0.09	0.65	0.58	0.42	0.16	1.12	0	0	0	0.07
Total	100.06	100.05	100.04	100.07	100.04	100.05	100.08	100.07	100.07	100.06	100.06	100.07	100.07

	High-Pb, Na-free glaze
	Moderate-Pb, Na-free glaze
	High-Pb, moderate-Na glaze/glass
	High-Na, low-Pb glass
	Pigmented clay (CuSO4.5H2O?)
	Ceramic body made from sedimentary iron-rich clay

Samples: T1. Light green glass tube found near Furnace #5, Myinkaba; T2. Deep opaque green glazed roof tile and associated ceramic body from Hmanzedi Pagoda; T3. Green glazed leaf-shaped ceramic fitting from Sulemani Temple; T4. Green glazed panel piece from Soeminghi Temple; T5. Blue glass found near Furnace #5, Myinkaba, Bagan; T6. Blue glass tube/bead found near Furnace #5, Myinkaba, Bagan; T7. Pigmented blue clay found near Furnace #5; T9. Yellow glass tube found near Furnace #5, Myinkaba, Bagan; T9A. Repeat analysis of yellow glass tube found near Furnace #5, Myinkaba, Bagan; T10. Yellow glazed fitting found on the surface at Sulemani Temple.

Myinkaba, central Myanmar as a site for glass making

The physical proof of a glass industry at Bagan includes the glass smelting and manufacturing furnaces; primary evidence of manufacture manifests as local finds of glass beads and associated wasters, jar crucibles containing mass glass, and appropriate furnaces. The ruins of the industry allow an interpretation of a well-developed industry with substantial furnaces of a sophisticated design, and a manufacturing system allowing several workers to operate independently at each furnace. The limitation of bead forms to a single oblate shape employing a specialized technology expresses the very essence of mass production and indicates that the industry was under no market pressure to provide a more sophisticated range of products.

It is very likely that more furnaces will be found at Myinkaba, which will further reinforce the case for large-scale production. Those that have been found were hidden in the ground until they were uncovered by extensive digging for gold during the post-war period. That the discovery of furnace #7 did not occur until 2003 was probably due to its protected location.

In the absence of local technical origins or experimentation that could explain the development of the industry at Bagan, introduction from another place must be assumed. The layer construction method used for the furnaces exists elsewhere in Burma at Pegu, suggesting at least some of the inspiration

Table 3. Comparative glass analyses from India and Southeast Asia.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SiO2	66.15	74.28	57.4	60.53	67.37	65.64	68.81	66.56	57.09	35.15	69.01	52.63	76.84	65.18
TiO2					0.53	0.53	0.49	0.34	0.57	0.36	0.27	0.3	0.l	0.2
Al2O3	4.64	1.94	7.86	9.96	8.87	9.88	8.08	4.81	5.52	3.75	5.79	10.01	3.37	10.05
MgO	2.01	0.82	1.84	1.28	0.45	0.9	0.95	0.62	1.03	0.48	0.68	1.87	0.27	0.19
MnO	0.14	0.97	0.08	0.11	0.08	0.06	0.06	0	0	0	0	0.18	1.01	0.04
FeO #	1.3	3	2.95	0.68	1.85	1.7	1.67	0.98	2.97	1.95	1.23	2.91	1.46	0.92
CaO	3.95	2.23	3.7	3.15	2.16	2.25	2.09	1.62	1.93	0.96	1.75	5.94	0.85	1.76
K2O	3.93	11.85			1.86	2.14	1.72	0.84	1.47	0.69	1.91	3.86	14.87	2.55
Na2O	14.04	1.77	22.47	20.76	14.56	16.51	16.64	18.23	22.49	8.46	16.85	11.07	0.24	16.44
P2O5[2]								0.52	0.52	0.15	0.87	1.19	0.1	0.09
PbO [3]	0.01	0.01						3.24	0.35	43.81	0.14	2.24	0.05	0.15
CuO	1.6	0.77	3.82	0.55				1.42	5.6	0.48	1.41	5.71	0.1	1.33
SnO2								0.51	0.12	3.83		0.88	bdl	0.15
SO2								0.37	0.42		0.16			
Total	97.77	97.64	100.12	97.02	97.73	99.61	100.51	100.06	100.08	100.07	100.07	98.79	99.16	99.05

Notation: # total Fe as Fe2O3 for sample numbers 1-7 and 12-14; 2 reported as P2O3 for sample numbers 12-14; 3 reported as PbO3 for sample numbers 12-14; bdl below detection level; na not analyzed for.

Samples: 1. Four samples of opaque red glass, Arikamedu, India (Francis 1990); 2. Five samples of various colored glasses, Arikamedu (Francis 1990); 3. Two sample groups of red (and ochre) glass, Óc Eo, Viet Nam (Francis 1990); 4. Four sample groups of other colored glass, Óc Eo, Viet Nam (Francis 1990); 5. Yellow glass bead (No 1), Sungai Mas (Ramli *et al.* 2011); 6. Green glass bead (No 14), Sungai Mas (Ramli *et al.* 2011); 7. Blue glass bead (No 13), Sungai Mas (Ramli *et al.* 2011); 8. Light green glass tube found near Furnace #5, Myinkaba, Bagan (T1 - this study); 9. Blue glass found near Furnace #5, Myinkaba, Bagan (T5 - this study); 10. Yellow glass tube found near Furnace #5, Myinkaba, Bagan (T9 - this study); 11. Blue glass tube/bead found near furnace #5, Myinkaba, Bagan (T6 - this study); 12. Orange bead (No. AKC01919) from Phnom Borei, Cambodia (Carter 2010); 13. Blue bead (No. AKC00729) from Bit Meas, Cambodia (Carter 2010); 14. Blue bead (No. AKC00090) from Phum Snay, Cambodia (Carter 2010).

might have come from within the country. As signs of glass production have been found in Bago (Hein 2003: 62) and Martaban, where large quantities of beads have been recovered (reported by Moore and San Win (2014), and witnessed by D. Hein), it is possible that in addition to the Mon king Munuha (said to have been captured by Anawratha in the mid-eleventh century AD and settled in Myinkaba; see Aung-Thwin 2005; Stadtner 2008), artisans, captive potters and glass bead makers from the Mon kingdom were also settled in Myinkaba sometime in the last century of the first millennium. The Mon are thought to have been advanced in the production of glazed ceramics. The context of the industry at Myinkaba and its stratigraphic order supports this chronology. Furthermore, it is significant that glazed bricks, such as those of the Ngakywenadaung Stupa, were being made by the tenth century AD, at which time glass beads may have already been in production. If in fact the large furnaces did make glazed fittings for eleventh and twelfth century monuments, the 'estimated' date for the glass furnaces offered by Pichard (1993) of the fourteenth century AD seems much too late. The present state of analytical study of the glazes supports but does not prove the possibility of dual use of the large furnaces as kilns and therefore the need of scientific dating is paramount.

Figure 23. Map of Indian and Southeast Asian glass bead sites (after Francis 1991b) with some recent additions. Map by D. Hein.

Over the past two thousand years, influence from the Middle East, especially through the port of Banbhore in Pakistan, brought ceramic and glass style and technology to India and Southeast Asia (Di Crocco 1990b). In the time of the Pyu culture in Burma (seventh to eleventh centuries AD), trade was developed particularly with the east coast of India, and it is possible that the technique of glazing was introduced into Burma during this period (Gutman 2001). To the contrary, Than Tun (1972-1973) says that excavations at Beikthano and Hanlin at the center of the Pyu Kingdom recovered no glazed ware. If true, the introduction of glazing must have come from some other source of influence, and the most credible claim is that source to be the Mon of Lower Burma (Stadtner 2008). Claims of a small number of glazed potsherds being found in Pyu sites may have the same significance as finds of tobacco smoking pipes in the same context, for which a chronology prior to the fifteenth century is impossible (Hein 1997).

Certain pottery techniques used in Burma are thought to have come from Arikamedu or one of its descendant sites on India's east coast or Ceylon. Francis (1991b: 28) suggested the glass bead industry in Southeast Asia probably was always 'in the hands of Tamil craftsmen' who moved from one coastal location to another to meet demand. Claims have been made of glass bead production at coastal sites including at Óc Eo in the Mekong delta in Viet Nam, Khlong Thom in southern Viet Nam, and Kuala Selinsing and Sungai Mas in Malaysia (Francis 1990; Glover and Henderson 1995; Cayron 2002; Ramli *et al.* 2011). Therefore, bead making in Burma probably also first occurred at a coastal site and later – perhaps on the capture and transfer of Manuha and his followers – extended to Bagan.

Assuming that a number of the manufacturing furnaces were contemporary, the number of beads potentially being produced would have been large, much more than would meet local demand. Therefore, the beads were probably to some degree made for trade, both inland and along the Ayeyarwaddy River

to join Indo-Pacific maritime commerce. The question of whether glass beads found in many insular locations were produced at coastal Mupon or Myinkaba in central Burma is currently being tested and will be published in a future paper.

Mass production implies industry, which in turn implies substantial infrastructure. In the case of glass artifacts made from raw materials (as opposed to traded cullet), the facility to smelt glass and to manufacture large numbers of beads demands suitable furnaces and associated infrastructure. Despite the ubiquity of mass-produced glass beads in archaeological contexts in Southeast Asia, their origins are generally uncertain. Based on bead and certain debris finds, claims have been made of glass bead production sites in Southeast Asia, but in most cases evidence of furnaces to prove manufacture has not been substantial. Myinkaba is a certain case of glass bead production whose infrastructure has existed in plain sight for fifty years, yet the significance of its discovery was lost due to misinterpretation. This paper serves to demonstrate that Burma should be included in the list of places that produced Indo-Pacific monochrome glass beads prior to the influence of Europeans.

Acknowledgements and dedication

Periodically between 1981-2003 Don Hein studied the 'kilns' at Myinkaba under the early inspiration of U Bo Kay, then Director of Archaeology at Bagan, and Aung Thaw, Director of the Archaeological Survey of Burma, often working with archaeologists of the Myanmar Department of Archaeology, especially Director Nyunt Han and Aung Kyaing, Senior Archaeologist of Bagan, and in consultation with Burmese scholars Myo Thant Tyn and Aung Bo of the Myanmar Ceramic Society, and at times in collaboration with other foreign scholars including Mike Barbetti (in 1988-1990; Hein and Barbetti 1988). Hein established that the structures were furnaces used in the production of glass beads of the Indo-Pacific monochrome drawn type. In 1999 he was invited to participate in the re-excavation of 'Kiln #1' to determine the accuracy of the Dello Strologo and Kyaw Nyein (1963) report findings. That excavation and following work distinguished smelting furnaces that made the raw glass from those furnaces designed for the manufacture of beads. At times the research was funded by the Australian Research Council (ARC), and assisted by the Australian Embassy in Yangon, with special acknowledgement to Ambassador Christopher Lamb. This paper is dedicated to the memory of Peter Francis 1945-2002, who committed his life to the study of the glass beads of Southeast and East Asia and for whom the discovery of Myanmar's important contribution came too late.

Appendix

Samples of ceramic bodies and glazes obtained from various itemized Bagan ceramics and glasses were mounted in epoxy blocks and polished. Each block was subsequently coated with a film of amorphous carbon (<3 nm) to prevent a build-up of charge during analysis. Quantitative chemical analyses were performed using a JEOL 840A scanning electron microscope (SEM) equipped with an Oxford Instruments ATW X-ray Energy Dispersive Spectrometer (XEDS). The microscope was operated at a high-tension of forty kV, the probe current was set at six Na and the working distance at thirty-nine millimeters. The resolution of the energy-dispersive detector was 147 Ev at 5.9 keV. Typically, the live time was 100 seconds. All spectra were acquired using a focused (~1 μm diameter) probe. Bulk compositions were determined by raster analyses of single fields using the maximum available area. All quantitative analyses involved applying the ZAF matrix correction procedure to the measured intensities of the Na-Kα, Mg-Kα, Al-Kα, Si-Kα, P-Kα, S-Kα, K-Kα, Ca-Kα, Ti-Kα, Fe-Kα, and Pb-Lα characteristic X-ray peaks. Oxygen content was calculated by difference based on the assumed stoichiometry of the oxides. The internal standards and references used in this investigation included apatite (Ca, P), anhydrite (S), plagioclase *An 65* (Al, Si), tugtupite (Na), sanidine (K), iron (Fe), lead (Pb), magnesium (Mg) and titanium

(Ti). The presence of trace quantities of other elements was confirmed by inspecting spectra by eye. Due to peak overlap, it was not possible to confirm visually for: (a) sulfur when lead was present, and (b) sodium when remote fluorescence from the copper sample holder gave rise to a Cu-L peak. In most instances results are regarded as +/- 5%.

The iron smelting technology of the Bujang Valley, Malaysia

Naizatul Akma Mokhtar and Mokhtar Saidin

This paper discusses smelting technology at the Sungai Batu SB2A iron smelting site in the Bujang Valley, Kedah, Malaysia, which was dated to the first to fifth centuries CE through radiocarbon, AMS-dating and OSL techniques. Findings at the site include iron slag, a fragment of tuyere, iron ore, laterite, brick, segments of a furnace wall, beads, ceramics, lithics and iron artifacts. This paper presents dating evidence, and discusses the results of XRF, XRD, SEM-EDX and metallurgy studies of the iron artifacts, slag and ore. The analyses suggest that iron smelting activities were carried out by employing the bloomery technique, using temperatures of 1150-1200°C, probably without using catalyst material or flux, and that Bukit Tupah is the resource area for haematite used at the site. The archaeological data suggest that prehistoric societies at Sungai Batu employed direct smelting techniques (Naizatul Akma Mokhtar et al. 2011), with the construction of a clay furnace and the use of tuyeres and bellows. The Bujang Valley appears to have functioned not only as a center of exchange for foreign commodities, but also of local industry. The ancient glory of the Bujang Valley as an entrepôt was not only due to its advantageous location, but also to the commodities that it was producing.

Introduction: history of research in the Bujang Valley

Archaeological studies in the Bujang Valley were initiated by James Low in the 1840s, when he stumbled upon the structural ruins of a caṇḍi and a Buddhagupta stone tablet in Cherok Tokun, Seberang Perai (Low 1848). This area later attracted fellow archaeologists, including Evans, Quaritch Wales and Lamb (e.g. Evans 1922, 1926, 1930; Quaritch Wales 1940, 1946; Lamb 1960, 1980a-c). In the 1970-1980s excavations were carried out by the Department of Museums and Universiti Kebangsaan Malaysia (Adi Taha 1989; Kamarudin Zakaria 2004; Nik Hassan Shuhaimi Nik Abdul Rahman and Othman Mohd Yatim 1992). Other archaeologists known to have worked in Bujang Valley are Leong Sau Heng (1973), Allen (1988, 2011), Jacq-Hergoualc'h (1992) and Mohd Supian Sabtu (2002).

The Bujang Valley is a 400 km^2 historical complex bounded by Bukit Choras in the north, Sungai Muda in the south, the Straits of Melaka in the east and the PLUS Highway in the west (Adi Taha 1998: 3) (Figure 1). It is also known as the oldest kingdom of Kedah Tua (literally 'Ancient Kedah'), a maritime trade center. Historical records of Kedah Tua state that this empire existed from the beginning of the first century to the late fourteenth century CE (Mokhtar *et al.* 2011: 24; Andaya 2011: 70). As early as the second century, there are recorded influences from Funan culture (Andaya 2011: 78). The kingdom was attacked by Srivijaya at around the seventh to eleventh century and by King Chola at around the fifteenth century. As a result of these attempts at colonization and trade interactions with other empires, Kedah Tua grew and gained popularity as a bustling, multi-cultural maritime port (Murphy 2017: 27; Naizatul Akma Mokhtar *et al.* 2011: 24; Leong Sau Heng 1990: 27).

Chinese, Arab and Indian merchants mention that Kedah Tua – also known as *Chieh-cha, Ch'ih-t'u, Kalah*, *Qaqullah, Kataha, Katahanagara, Kalagam, Kidaram* or *Kandaram* – was a successful entrepôt (Wheatley 1961: 273-281; Braddell 1989: 343). Kedah Tua was located strategically in the middle of an east-west trading route and was popular among traders and sailors waiting for the changing monsoon season. Traders were also enticed by the wealth of available local resources such as tin ore, gold and forest products (sandalwood, camphor, ivory, rhino horns, beeswax, incense) (Wheatley 1961: 273-281; Leong Sau Heng 1980: 5; Allen 1988: 209, 532; Braddell 1989: 346).

Findings from those studies have proven that Kedah Tua was a maritime trade center or entrepôt. Remapping of the Bujang Valley in 1987-1988 recorded eighty-seven archaeological sites identified to

Figure 1. Location of archaeological sites and SB2A in the Bujang Valley. Map after Naizatul Akma Mokhtar et al. *(2011).*

have served various functions (Allen 1988: 287-410). As many as eighteen of these are estimated to be trade markets based on ceramics and beads (*ibid*.). However, all findings and studies on Bujang Valley have unearthed no evidence of iron-smelting activities, although in old documents we find mentions of an ancient sword from Bujang Valley, at the time known as Qalai (Kalah); this was noted as one of three excellent sword-making locations, in addition to Yemen and India (*Hindi*) (Mokhtar *et al.* 2011: 23; Singaravelu Sachithanantham 2011: 190; Hoyland and Gilmour 2006: 19). Of the various names for the locale, *Kataha* is Sanskrit, and three names are Tamil: of these *Kadaram* and *Kidaram* are variants of the same word which has the same meaning as *Kataha*; *Kalagam* – meaning 'black' – is synonymous with *Kadara*, also Sanskrit, meaning 'tawny' or 'dark brown', which is represented as 'black iron', and it was said that this related to high-quality ores (Braddell 1989: 344).

Archaeological research in SB2A, Sungai Batu

The Sungai Batu site was first discovered during a survey in 2008 (Mokhtar *et al.* 2011: 19). A survey of Sungai Batu estates, an area of three square kilometers, revealed a total of ninety-seven mounds, potential protohistoric sites (*ibid*.: 20). SB2A site is one of these mounds, located at longitude 100°27.277' East and latitude 5°41.651' North, and eleven meters above sea level (based on GPS readings at the site datum point). It is situated approximately ten kilometers from Sungai Petani and eighty kilometers from the town of Alor Star, Kedah Darul Aman (Figure 1). The site was mapped as site no. 71A by Allen in 1987, and said to be the site of a caṇḍi based on the discovery of bricks identified as remnants of the temple (Allen 1988: 384; 2011: 148).

Excavations have uncovered artifacts and features such as iron slag, tuyere fragments, iron ore fragments, and deposits possibly indicative of a furnace, such as ash and charcoal (Figure 2). Based on those artifacts and features, it can be surmised that the site was once used for iron smelting activities. In fact, the distribution of artifacts and features seems to indicate spatial compartmentalization for dedicated activities at the site. These dedicated workspaces can be seen both horizontally and vertically in the stratigraphy of the site (Naizatul Akma Mokhtar *et al.* 2011).

The site has between seven to ten stratigraphic layers (Figures 3-4). Cultural layers start at the fourth and fifth layer. Based on the context of the artifacts, the site was not disturbed by recent agricultural activities. Studies on soil layering indicated the presence of different layers coexisting at the same time, hinting that different activities or histories were happening over space in the same layer. This was clearly observed in trenches P9-P15 and Q7-M7. The stratigraphic sequence of P9-P15 showcases the transition of a work area (iron-smelting activities) into an area for dumping a pile of tuyeres. Meanwhile, Q7-M7 was an area prominently dedicated to iron-smelting activities.

Fourteen samples were dated using conventional radiocarbon dating, Accelerator Mass Spectrometry (AMS), and one sample by Optically Stimulated Luminescence dating (OSL). Charcoal samples were sent

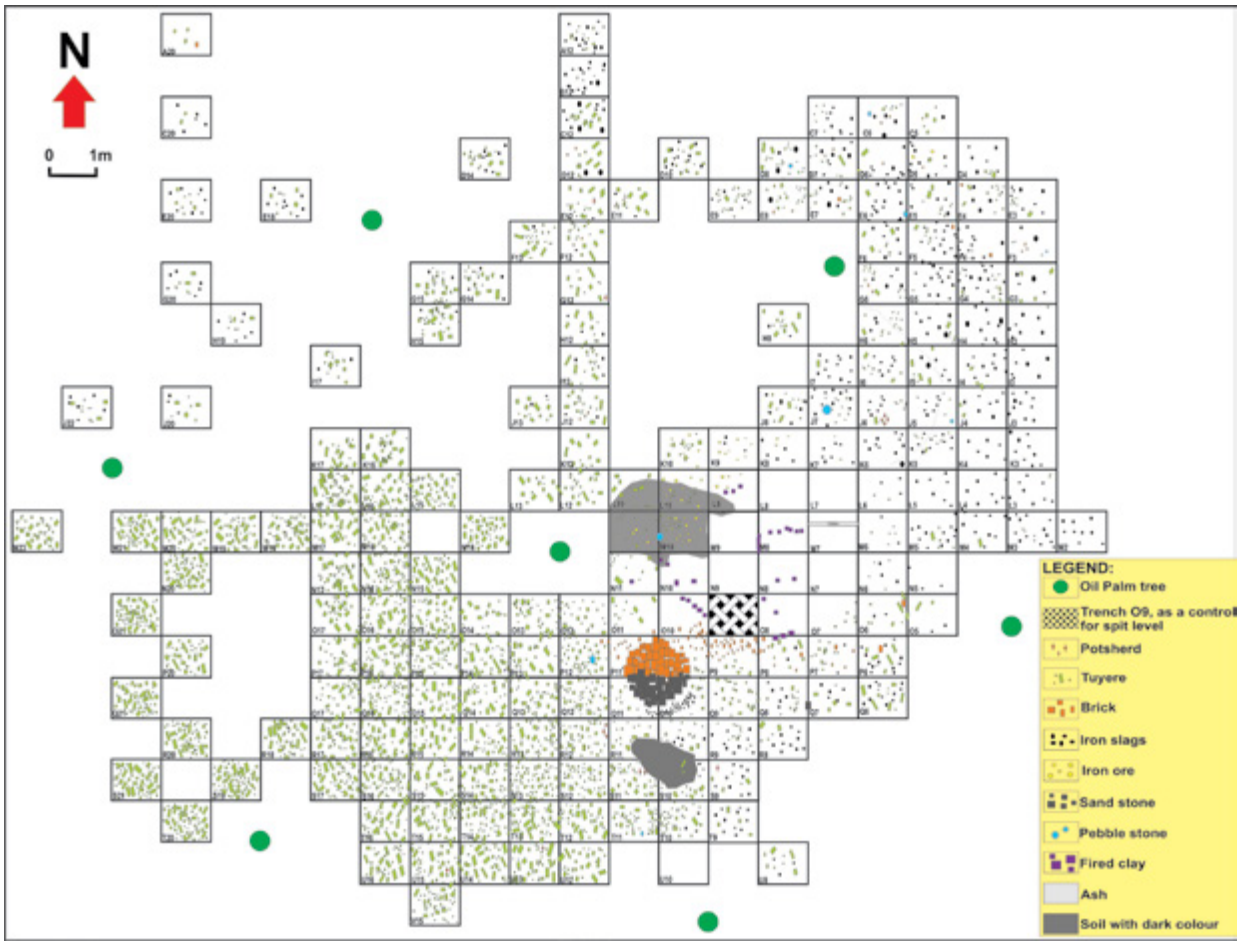


Figure 2. Distribution of findings at SB2A according to trenches. Map by Naizatul Akma Mokhtar and Mokhtar Saidin.

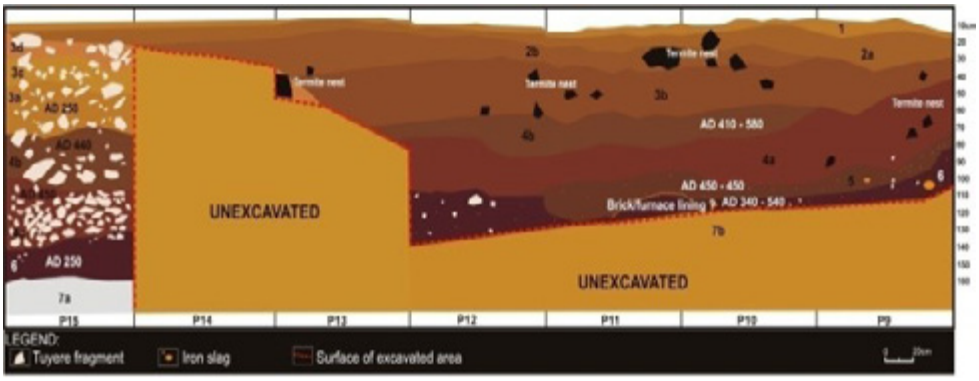


Figure 3. Stratigraphy of trenches P9-P15; from Naizatul Akma Mokhtar et al. *(2011).*

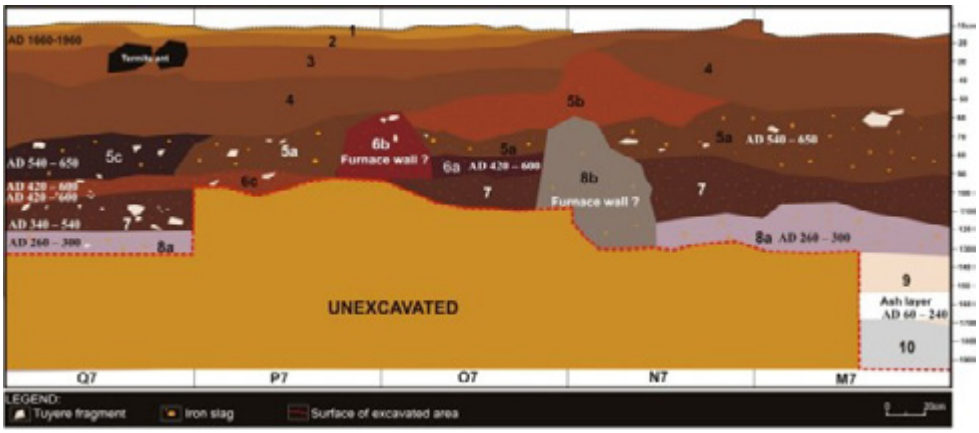


Figure 4. Stratigraphy of trenches Q7-M7; from Naizatul Akma Mokhtar et al. *(2011).*

to Beta Analytic Inc. for radiocarbon dating, while OSL dating was performed on tuyere samples sent to the Korea Basic Science Institute. Chronometric dating indicates that SB2A was occupied from as early as the first to fifth century CE. Iron-smelting activities only took place actively from the third to fifth century (Table 1).

The excavations have revealed a host of artifacts and ecofacts (Naizatul Akma Mokhtar *et al.* 2011). Artifacts found on the site consist of metal artifacts, stone tools, potsherds, ceramic pieces, beads, broken bricks, furnace wall fragments, laterite, iron ore, iron slag and broken tuyeres. The ecofacts retrieved were shells, charcoal, ash and burnt clay. Artifacts make up the bigger fraction of the discoveries, totaling 2,888,423.29 grams (276,215 pieces) (Table 2). Of the total weight and number of artifacts discovered, 66% of the total weight or 74% of the total number of artifacts are metal, comprising iron artifacts, iron ore and slag. Of these, iron slag makes up 93.387% of the total amount, or 91.683% in terms of weight (Table 3).

The main morphological features of the SB2A iron slag are: 1) no fixed form, 2) a flowing texture such as lava or grating surfaces, 3) dark gray to strong brown in color, (4) of different densities, 5) the presence of porosity, and 6) a magnetic response. The forms or shapes of the slag pieces generally fall into one of the four following groups: plano-convex, semicircle or circular, amorphous without a base, and amorphous with a base (Figures 5-7). Iron ores recovered from SB2A (Figures 8-10) consist of 99.2% haematite, 0.33% magnetite and 0.47% laterite. Haematite ores were predominantly found at this site compared to other types of ore.

Table 1. Chronometric dating from site SB2A within selected trenches

Lab. No.	Trench	Spit	Dating method	**Conventional age (BP)**	**Calibrated age (AD)***	**Artifact**
Beta-268001	M7	16	AMS/org. matter	1860±40	60-240	clay, charcoal
Beta-276049	P15	15	RC/charcoal	1690±40	250	tuyere
Beta-276046	P15	7	RC/charcoal	1680±40	250	tuyere, slag
Beta-268005	M11	7	AMS/charcoal	1660±40	260-290	tuyere, slag
Beta-268003	Q7	12	AMS/charcoal	1670±40	260-300	tuyere, slag
Beta-268000	O10	11	AMS/charcoal	1630± 40	340-540	tuyere, slag
Beta-268002	M7	17	AMS/charcoal	1570±40	410-580	clay, charcoal
Beta-267998	O10	8	AMS/charcoal	1570±40	410-580	tuyere, slag
Beta-258294	Q7	9	RC/charcoal	1600±40	420-600	tuyere, slag
Beta-258295	Q7	10	RC/charcoal	1590±40	420-600	tuyere, slag
Beta-276047	P15	10	RC/charcoal	1500±40	440	tuyere, slag
Beta-276048	P15	13	RC/charcoal	1490±40	450	tuyere
Beta-267999	O10	9	AMS/charcoal	1490±40	450	tuyere, slag
-	Q21	8	OSL/tuyere	1550±46	459	tuyere
Beta-256964	O8	8	RC/charcoal	1460±40	540-650	tuyere, slag

*Calibration via INTCAL04 (Reimer *et al.* 2004) database for radiocarbon dating.

Figure 5. Iron slag with plano-convex shape. Photo: Naizatul Akma Mokhtar and Mokhtar Saidin.

Table 2. Total artifacts found at SB2A

Artifacts	**Number**	**%**	**Weight (g)**	**% wt**
Metal artifacts	204,893	74	1,900,966.77	66
Other artifacts	71,322	26	987,456.52	34

Table 3. Metal finds at SB2A

Find	**Number**	**%**	**Weight (g)**	**% wt**
Metal artefact	10	0.005	266	0.014
Iron ore	13,540	6.608	157,842.40	8.303
Iron slag	191,343	93.387	1,742,858.37	91.683

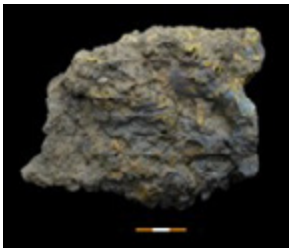


Figure 6. Iron slag with semicircle shape. From Naizatul Akma Mokhtar and Mokhtar Saidin (2018a: photo 8).

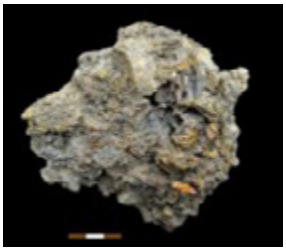


Figure 7. Iron slag, amorphous with a base. From Naizatul Akma Mokhtar and Mokhtar Saidin (2018a: photo 8).

Among the most notable metal objects found are a blade in the shape of a sickle, a blade with a nozzle-like top, a metal ring and a bronze bracelet (Figures 11-12). The bronze bracelet has an imperfectly circular shape with a surface of emerald green. The metal ring is covered with a white layer with some brown spots determined to be earth stains.

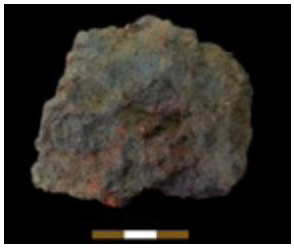


Figure 8. Haematite. From Naizatul Akma Mokhtar and Mokhtar Saidin (2018a: photo 1).

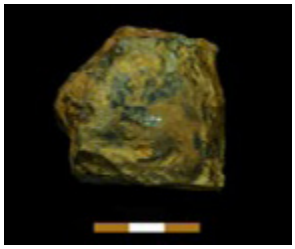


Figure 9. Magnetite. Photo: Naizatul Akma Mokhtar and Mokhtar Saidin.

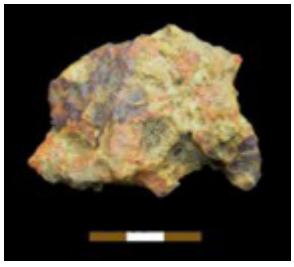


Figure 10. Laterite. Photo: Naizatul Akma Mokhtar and Mokhtar Saidin.

Scientific analysis

Mineralogy and chemical composition studies on samples of iron slags, iron ore and metal artefacts were carried out to determine the smelting techniques employed at the site, and the melting temperature obtained during smelting and iron ores sources, using X-ray fluorescence (XRF), X-ray diffraction (XRD), scanning electron microscope (SEM), energy dispersive X-ray spectroscopy (EDX) and metallurgy. XRF and XRD analyses were done at the Department of Minerals and Geoscience, Ipoh, Perak, on five samples of slag and two samples of iron ore collected from SB2A site, as well as iron ore samples from four survey locations (Universiti Teknologi Mara (UiTM), Merbok, Kg. Sg. Batu, Kg. Batu 5 and Bukit Tupah; Figure 13). See Naizatul Akma Mokhtar *et al.* (2011) for additional analyses.

Figure 11. Blades I (top) and II (bottom). Photos: Naizatul Akma Mokhtar and Mokhtar Saidin.

X-ray fluorescence (XRF)

XRF analysis of iron ore samples from UiTM, Kg. Sg. Besi, Kg. Batu 5, Bukit Tupah, and two samples from SB2A showed the presence of SiO_2, Al_2O_3, TiO_2, Fe_2O_3, MnO, CaO, MgO and P_2O_5 (Tables 4-5). Samples from UiTM and Bukit Tupah yielded lower SiO_2 and Al_2O_3 content, with a higher percentage of Fe, compared to samples from Kg. Sg. Besi and Kg. Batu 5. XRF analysis showed that the samples from UiTM and Bukit Tupah are iron ores with more potential to be used as raw materials for smelting than samples from Kg. Sg. Besi and Kg. Batu 5, because they have a higher iron content. An Fe content of less than 55% indicates that samples A1 and A2 are haematite because magnetite ore in its natural state contains about 72.4% Fe (Rostoker and Bronson 1990: 42).

Comparative analysis of the ratio between manganese and titanium to determine the source of iron ore clearly showed

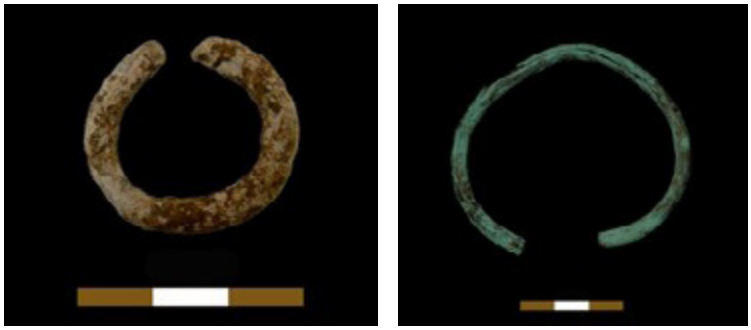


Figure 12. Metal possible ring (left) and bronze bangle (right).
Photos: Naizatul Akma Mokhtar and Mokhtar Saidin.

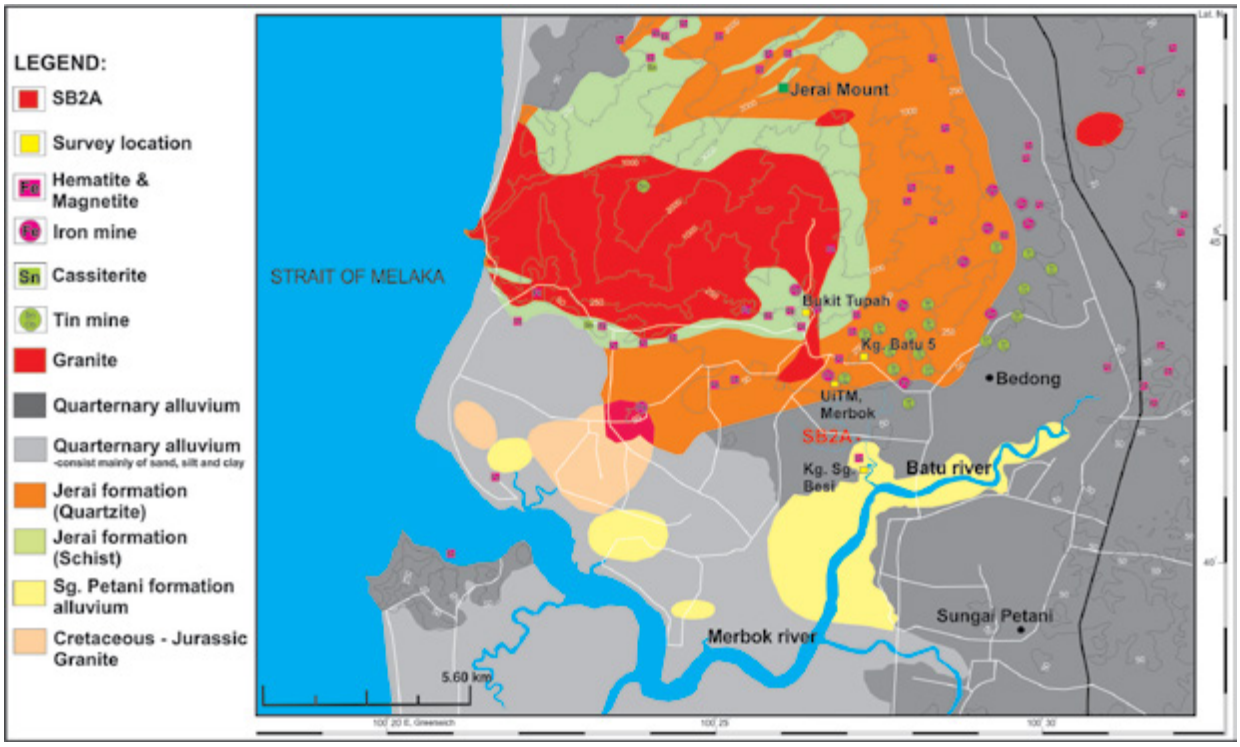


Figure 13. The location of iron ore survey and mineralogy distribution at Bujang Valley area.
From Naizatul Akma Mokhtar and Mokhtar Saidin (2018a).

that samples of iron ore A1 (1: 0.1) and iron slag B1 (1: 0.3) from SB2A site had a similar ratio to iron ore from Bukit Tupah (1: 0.1) (Table 6). This suggests that the iron ores used for smelting at SB2A may have been from a source similar to Bukit Tupah, while iron ore A2 samples are likely to have originated from other sources. Manganese and titanium were chosen for comparative analysis as these elements are not affected by the chemical reactions involved in smelting and remain in the slag after smelting (Tylecote 1962: 182; Friede 1982: 41; Heimann *et al.* 2001: 233).

Table 4. Results of XRF analysis of iron slag samples (in weight percent)

Compounds	Iron slag (wt%)				
	B1	B2	B3	B4	45
SiO_2	12.13	16.49	17.64	12.14	19.04
TiO_2	0.14	0.24	0.25	0.13	0.22
Al_2O_3	5.56	6.62	7.01	5.14	7.23
Fe_2O_3	72.17	65.21	63.32	79.13	65.77
MnO	0.42	0.24	0.20	0.37	0.24
MgO	0.36	0.51	0.48	0.49	0.44
CaO	0.60	1.23	0.65	0.41	0.32
Na_2O	0.04	0.07	0.10	0.05	0.05
K_2O	0.25	0.55	0.28	0.14	0.23
P_2O_5	0.56	0.52	0.33	0.38	0.35
Cl	-	-	-	1.05	-
Co_3O_4	-	1.60	-	-	-
Gd_2O_3	-	2.91	-	-	-

Table 5. Results of XRF analysis of iron ore (in weight percent)

Sample	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	MnO	CaO	MgO	P_2O_5	Fe
UiTM	1.76	1.04	0.03	90.22	0.05	<0.01	0.01	<0.01	63.1
Kg. Sg. Besi	7.63	6.45	0.19	82.93	0.03	<0.01	<0.01	0.01	58
Kg. Batu 5	8.21	5.11	0.21	81.78	0.06	<0.01	<0.01	0.01	57.2
Bukit Tupah	2.37	2.02	0.07	90.22	0.27	<0.01	<0.01	0.01	63.1
A1 (SB2A)	3.25	1.66	0.04	75.21	0.46	0.03	<0.01	0.04	52.6
A2 (SB2A)	16.5	4.21	0.55	73.63	0.41	0.03	<0.01	0.04	51.5

Table 6. Comparison of MnO:TiO ratio between iron ore and iron slag samples

Type of sample	Name of sample	% MnO	% TiO	MnO: TiO ratio
Iron ore	UiTM	0.05	0.03	1: 0.6
	Kg. Sg. Besi	0.03	0.19	1: 6.3
	Kg. Batu 5	0.06	0.21	1: 3.5
	Bukit Tupah	0.27	0.07	1: 0.3
	A1 (SB2A)	0.46	0.04	1: 0.1
	A2 (SB2A)	0.41	0.55	1: 1.3
Iron slag	B1 (SB2A)	0.42	0.14	1: 0.3
	B2 (SB2A)	0.24	0.24	1: 1.0
	B3 (SB2A)	0.20	0.25	1: 1.3
	B4 (SB2A)	0.37	0.13	1: 0.4
	B5 (SB2A)	0.24	0.22	1: 0.9

X-ray diffraction (XRD)

Results of analysis done on the same five slag samples show the presence of fayalite, chondrodite, wustite, leucite, goethite, magnetite, quartz and haematite, while the iron ore samples contain magnetite, iron oxide, quartz, haematite, sillimanite, aluminum oxide and goethite (Table 7). The differences in mineral contents of the other iron ores when compared with the iron ore at SB2A are attributed to the SB2A ore sample having been through a roasting process, during which some minerals may have melted away (e.g. Rostoker and Bronson 1990: 52).

Table 7. Results of X-ray diffraction (XRD) analysis

Type of sample	Sample no.	Mineral composition
Iron slag	B1 (SB2A)	Fayalite [$Fe_2(SiO_4)$], chondrodite [$Ca_5(SiO_4)_2(OH)_2$]
	B2 (SB2A)	Fayalite [$Fe_2(SiO_4)$], wustite [FeO], leucite [$KalSi_2O_6$]
	B3 (SB2A)	Goethite [FeO(OH)], magnetite [Fe_3O_4], quartz [SiO_2], wustite [FeO]
	B4 (SB2A)	Fayalite [$Fe_2(SiO_4)$], magnetite [Fe_3O_4], wustite [FeO]
	B5 (SB2A)	Haematite [Fe_2O_3], quartz [SiO_2]
Iron ore	UiTM	Haematite [Fe_2O_3], sillimanite [Al_2SiO_5]
	Kg. Sg. Besi	Haematite [Fe_2O_3], quartz [SiO_2], aluminium oxide [Al_2O_3]
	Kg. Batu 5	Haematite [Fe_2O_3], quartz [SiO_2]
	Bukit Tupah	Magnetite [Fe_3O_4], iron oxide [Fe_2O_3], quartz [SiO_2]
	A1 (SB2A)	Haematite [Fe_2O_3]
	A2 (SB2A)	Haematite [Fe_2O3], goethite [FeO(OH)]

Metallurgy

Metallurgical analysis via reflected light microscopy was conducted to study the structure of opaque minerals such as iron oxides. The different phases or minerals in the metal samples are identified based on tonal variations of grey (Chirikure and Rehren 2004: 142). Two samples, one of iron slag (sample B2) and the other of iron ore (sample A2), were selected for analysis.

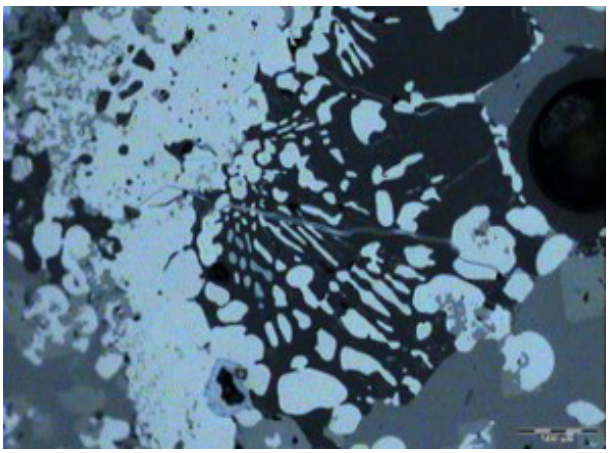


Figure 14. Photomicrograph of iron slag showing the presence of metallic iron (Fe; lighter areas), wustite (Wus; light grey patches in dark grey), fayalite (Fay; dark grey) and silicate as matrix. Scale bar is 500 µm. From Naizatul Akma Mokhtar and Mokhtar Saidin (2018b: photo 3).

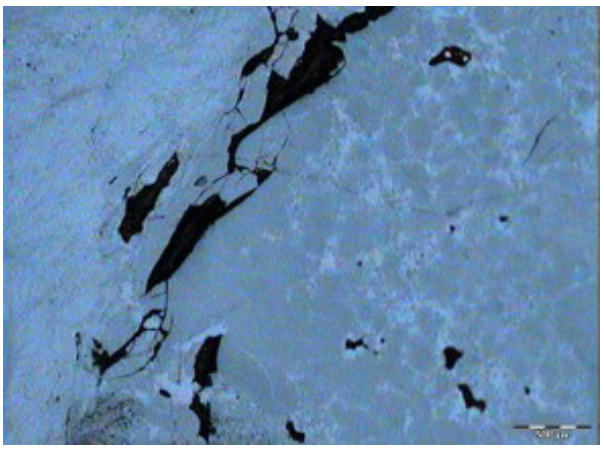


Figure 15. Photomicrograph of iron ore showing the presence of primary haematite (He) (light grey zones, including most of the area to the left of the image). Scale bar is 500 µm. From Naizatul Akma Mokhtar and Mokhtar Saidin (2018b: photo 4).

Photomicrographs of slag sample B2 show a structure containing 40% metallic iron (white shimmer), 10% wustite (light grey in color, slightly spherical and irregular shapes), 30% fayalite (grey) (Figure 14); these were also evident in the XRD results of XRD. Fayalite mineral deposits are formed by excess oxides in the iron ores, such as silicon dioxide (SiO_2), removed by the formation of the residual molten slag, iron silicate or fayalite ($FeSiO_4$) or ($2FeO.SiO_2$) (Blomgren and Tholander 1986: 152). The presence of large areas of fayalite structure also indicates that the cooling process occurred at a slower rate, giving the fayalite structure more time to grow (Humphris 2010: 48). 30% of the slag matrix consisted of silicate minerals.

Photomicrographs of iron ore sample A2 showed the original texture of primary mineral haematite covering almost 80% of the sample (Figure 15). This ore sample has a porous structure and contains 20% silicate which makes up its matrix. XRD analysis (above) of these samples shows the presence of haematite in the iron ores.

Scanning electron microscope energy dispersive X-ray spectroscopy (SEM-EDX)

SEM-EDX analysis was run on blades I, II, the metal ring and bronze bracelet by the laboratory at Hi-Tech Instruments, Penang, Malaysia. Blades I and II (Figures 16-18) contain markedly different elements and composition compared to the iron slag recovered from SB2A (Table 8). Blade 1 had a high percentage of CaO (0.87%), while the second blade contained SO_3. The high CaO content and presence of SO_3 are not reflected in the iron ores and slags found at the site. Meanwhile, the metal ring contained mostly PbO_2, a high content of 87.15% clearly indicating that it is made of lead alloy. The obvious non-similarity between the chemical composition of the metal artefacts and the iron slag samples studied here suggest that the metal tools were not related to these slag samples, and were perhaps not produced at this site, although many additional slag analyses would be required to state categorically that they were produced elsewhere. However, we have no clear finds related to lead metal production, so it is possible to be more convinced that this ornament, at least, is from elsewhere.

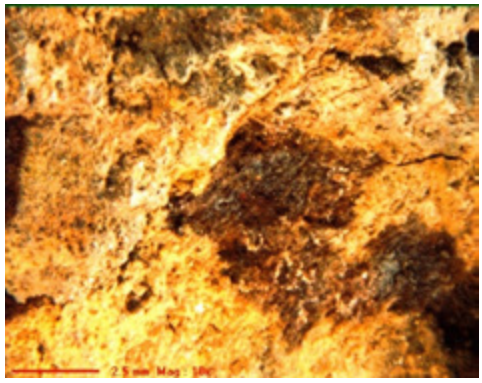


Figure 16. Photomicrograph of blade I. Red bar is 2.5 millimeters; from Naizatul Akma Mokhtar et al. *(2011: photo 9).*

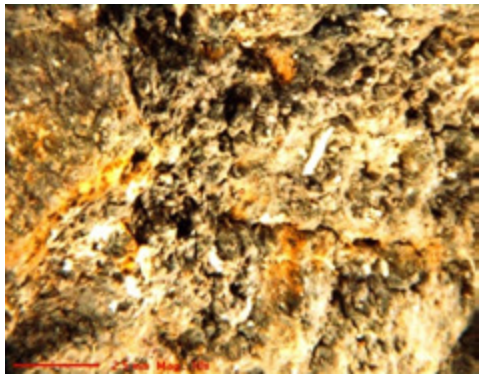


Figure 17. Photomicrograph of blade II. Red bar is 2.5 millimeters; from Naizatul Akma Mokhtar et al. *(2011: photo 10).*

Table 8. Results of SEM-EDX analysis of blade I, II and metal ring (in weight percent), from Naizatul Akma Mokhtar et al. *(2011: Tables 6 and 7).*

Compound	Blade I	Blade II	Metal ring
Al_2O_3	15.82	11.63	-
SiO_2	33.91	29.17	11.19
K_2O	0.20	-	-
CaO	0.87	0.18	-
TiO_2	0.35	-	-
SO_3	-	0.30	-
Fe_2O_3	48.86	58.71	1.66
PbO_2	-	-	87.15

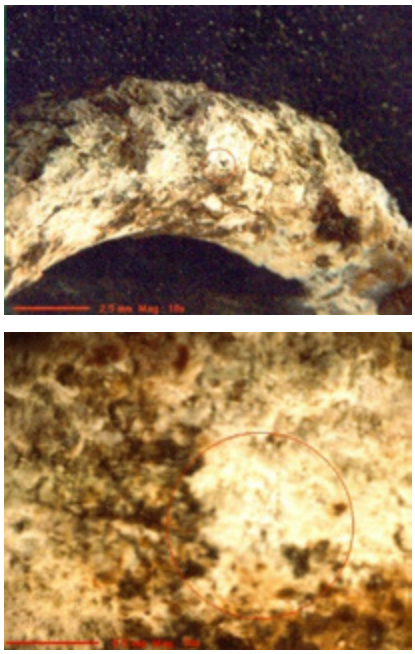


Figure 18. Photomicrographs of metal ring, from Naizatul Akma Mokhtar et al. (2011: photo 11). Upper image scale bar is 2.5 mm; lower image scale bar is 8.5 mm.

Interpretation

Metallurgical studies conducted on the iron slags, iron ores and other artefacts support the initial hypothesis that iron smelting occurred on the site in the first to fifth centuries CE using the direct or 'bloomery' process. This involved reducing part of the iron oxides of the charge to metal particles that coalesced to form a bloom, consisting of iron uniformly mixed with slag that required hammering to become wrought iron (Rostoker and Bronson 1990: 89; Tylecote 1992: 188). The discovery of 33,664 pieces of iron slag clearly identifies this site as a place that witnessed large-scale iron production, possibly on a long-term basis.

Chemical analysis on the slag samples from the site suggests that the smelting process must have been rather ineffective based on the 63-70% iron oxide content remaining in the slag. The high iron content in the slag either means the chemical reaction from the introduction of flux did not yield the desired result, or that flux was not used during smelting at all (e.g. Veldhuijzen 2005: 299; Venunan 2011: 59). Samples of iron slags contained 12-19% SiO_2. The presence of silica in at least small amounts is essential for successful smelting of iron. Silica present in the soil vitrifies when exposed to the high temperatures created by combustion for smelting; this in turn lowers the combustion temperature (Venunan 2011: 59). Abundance of silica is also helpful for removing iron oxides from the ore by transforming the oxides into fayalite (Veldhuijzen 2005: 299).

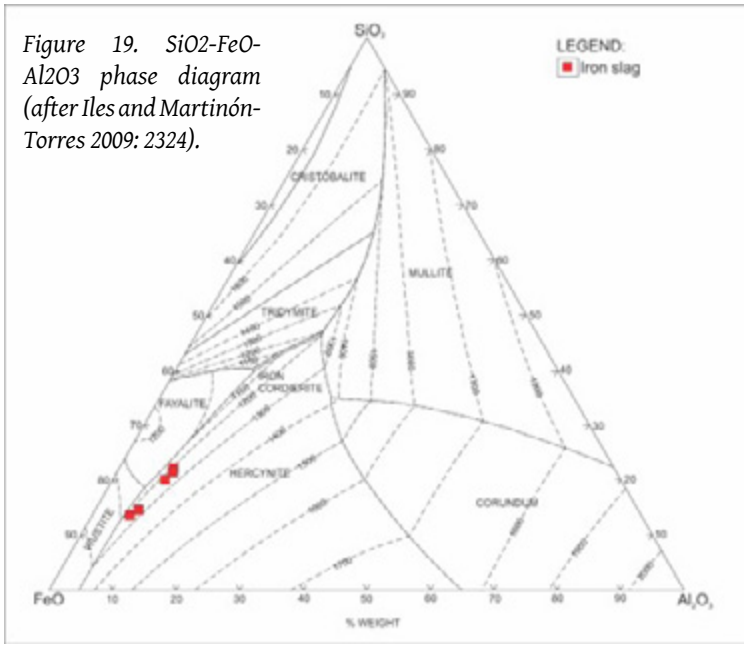


Figure 19. SiO2-FeO-Al2O3 phase diagram (after Iles and Martinón-Torres 2009: 2324).

The existence of bloomery furnaces at the site can also be supported by the ternary phase diagram of FeO-Al_2O_3-SiO_2, which shows the B1-B2 sample plotted in the wustite phase at a melting temperature of 1150-1200°C, while samples B3-5 plots in the fayalite phase at a melting temperature of 1150-1200°C (Figure 19). Bloomery iron is not normally heated above about 1250°C (Tylecote 1992: 188). Comparing the ratio between manganese and titanium content suggests a similarity between

Bukit Tupah samples and iron ore A1 and iron slag B1. This shows that an ore like the one from Bukit Tupah is one probable source for iron smelting at SB2A. The fact that this ore source is only about seven to eight kilometers from the site makes this a very likely source of origin for the iron ore.

XRD analysis shows that the five slag samples contain fayalite, chondrodite, wustite, leucite, goethite, magnetite, low quartz and haematite. The presence of fayalite and wustite in the sample shows that bloomery furnaces were used for iron smelting at SB2A, because these phases are only created at temperatures between 1150-1200°C. Polished section analysis of sample B2 also showed that it contains 30% wustite and 10% fayalite. Sample analysis indicates the presence of magnetite, iron oxide, quartz, haematite, sillimanite, aluminium oxide and goethite. Samples A1 and A2 also contained haematite, suggesting that haematite was the main ore used by the smelters. Polished section analysis on sample A2 also shows that 80% of the surface area studied is covered by haematite. This clearly demonstrates that this sample, with its high iron content, was suitable for iron extraction.

Conclusion

Archaeological studies of site SB2A have revealed a relatively undisturbed site rich with iron slag, iron ore and tuyere fragments distributed across the entire site. The discovery of furnace remains in addition to these objects clearly shows that SB2A site was once used for smelting iron, which involved the process of transportation of raw materials to the site, the preparation of iron ore and construction of furnaces fitted with tuyeres to achieve required temperatures for smelting (Naizatul Akma Mokhtar *et al.* 2011). The furnaces recovered are bloomery-type furnaces capable of reaching melting temperatures between 1150-1200°C. The bloomery process was not particularly efficient based on the high iron content in iron slags (63-79% Fe_2O_3). The smelters did not appear to introduce any catalyst or flux to the smelting process, based on the presence of less than 1% CaO in the iron slag. Haematite ore, possibly local, was one of the main sources of iron used on the site. Overall, the discovery of this iron smelting site, which dates as early as the first to fifth century CE, has shed new light on another important role played by the ancient civilization that populated the Bujang Valley centuries ago, other than as a famous entrepôt. The product from this iron industry was in ingots which were then traded. Smelting activity at SB2A went on for over five centuries, supported by its strategic positioning, which included good transportation systems, trade facilities, and rich resources of raw materials such as iron ore, clay and fuel.

Guide to understanding Khmer stoneware characteristics, Angkor, Cambodia

Chhay Rachna, Tho Thon and Em Socheata

Khmer stoneware technology first appeared in the ninth century CE in what is now northwest Cambodia and probably also in northeast Thailand, and production continued until at least the fourteenth century CE. The technical study of these stoneware kilns allows us to understand how and when Khmer potters developed this stoneware technological tradition. This study reviews stonewares recovered from excavated Khmer kilns and from recently excavated Angkorian sites to offer insights on Khmer stoneware production. Work concentrates on each well-documented stoneware production center in the Greater Angkor region and reviews our knowledge of Khmer stoneware production from northeast Thailand, using published information from sites in Buriram Province.

Introduction

Archaeological fieldwork in the Greater Angkor region since the mid-1990s has included a growing number of excavations on Khmer stoneware kiln sites (Figure 1): seven kiln sites in the Greater Angkor region and one in southern Cambodia (Phnom Penh). Ea Darith's (2010) dissertation summarizes work up to 2010 at several sites: Tani (TK), Thnal Mrech (TMK) or Anlong Thom kiln (ALK), Sorsei (SK), Khnar Po (KPK), and Bangkong (BK). Several more kilns have been excavated since then by the collaborative projects between APSARA Authority, the Institute of Southeast Asian Studies (National University of Singapore), the Freer/Sackler Smithsonian Institution, and the Royal Academy of Cambodia. These include portions of Torp Chey (TCK) in 2011, the Cheung Ek (CEK) kiln site in 2012-2013, and the Chong

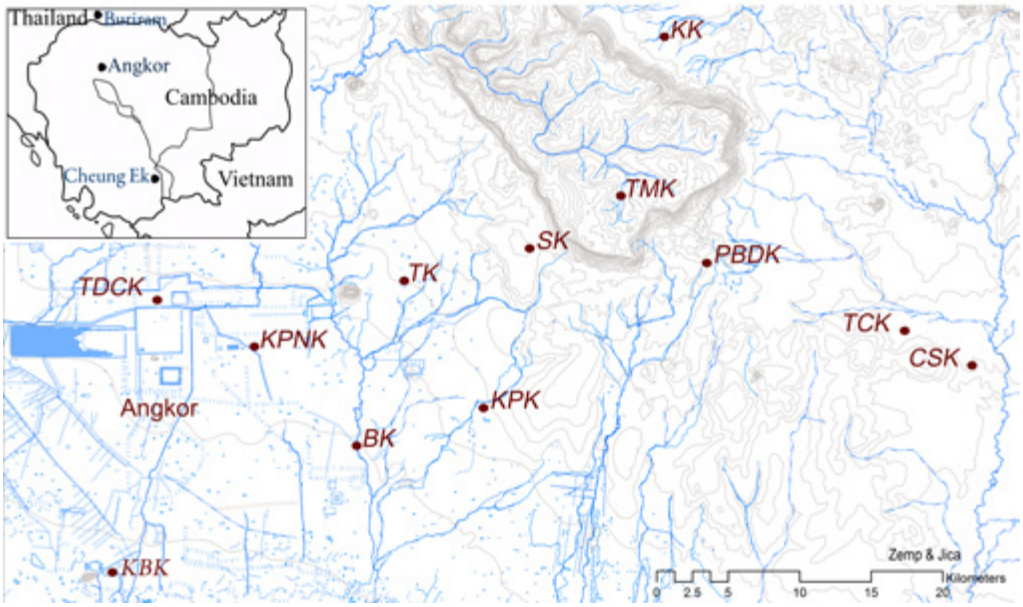


Figure 1. Ceramic (both earthenware and stoneware) production centers in Greater Angkor that have been excavated since 1995; including BK (Bangkong), CSK (Chong Samrong), KPK (Khnar Po), SK (Sorsei), TK (Tani), TMK (Thnal Mrech), and TCK (Torp Chey). Map by APSARA Ceramic Team.

Samrong (CSK) site in 2013. Most of the excavated stoneware kilns are located at some substantial distance from the urban epicenter of Angkor; some are found on Phnom Kulen. Very few stoneware kilns or earthenware production centers have been documented in the central portion of Greater Angkor; these include Kantout (KK), Poeng Bos Damlong (PBDK), Kok Phnov (KPNK), Kok Bey (KBK), and Thvea Dei Chhnang (TDCK) (Brotherson and Chhay Rachna 2012; Heng Piphal *et al.* 2012).

Work continues on analysis of materials from these excavations, and has been published in myriad venues (e.g. Sugiyama *et al.* 2005; Aoyagi and Sasaki 2007; Tabata and Chhay Visoth 2007; Tabata 2008; Hendrickson 2008; Miksic *et al.* 2009; Chhay Visoth *et al.* 2009, Chhay Rachna *et al.* 2009, 2010, 2013a, 2013b; Hirooka *et al.* 2009, 2011; Ea Darith 2010, 2015; Phon Kaseka *et al.* 2012; Hein *et al.* 2013). This growing literature on stoneware kilns already offers insights on kiln technology associated with Khmer stonewares. Hein (2008: 16-17) suggests that Khmer potters used crossdraft kilns to fire their glazed and unglazed stoneware vessels, figurines, and architectural elements. Figure 2 illustrates the crossdraft structure exposed through excavations of the Thnal Mrech Kiln 02, Cheung Ek kiln 17, and Torp Chey kiln. The size and configuration of stoneware kilns varies considerably.

In contrast with this recent burst of archaeological activity on Khmer stoneware kilns in the Angkorian region, little work has been done on Khmer stoneware kilns in northeast Thailand for nearly three decades. The Khorat Plateau's most famous stoneware production centers are found in Buriram Province and were excavated in the mid-1980s by the Thai Fine Arts Department (Srisuchat 1989; Srisuchat and Srisuchat 1989; Natthaphat 1990). Cultural material from excavated kilns and artifacts uncovered from Angkorian occupation sites provide an understanding of Khmer stoneware ceramic production (Chhay Rachna *et al.*

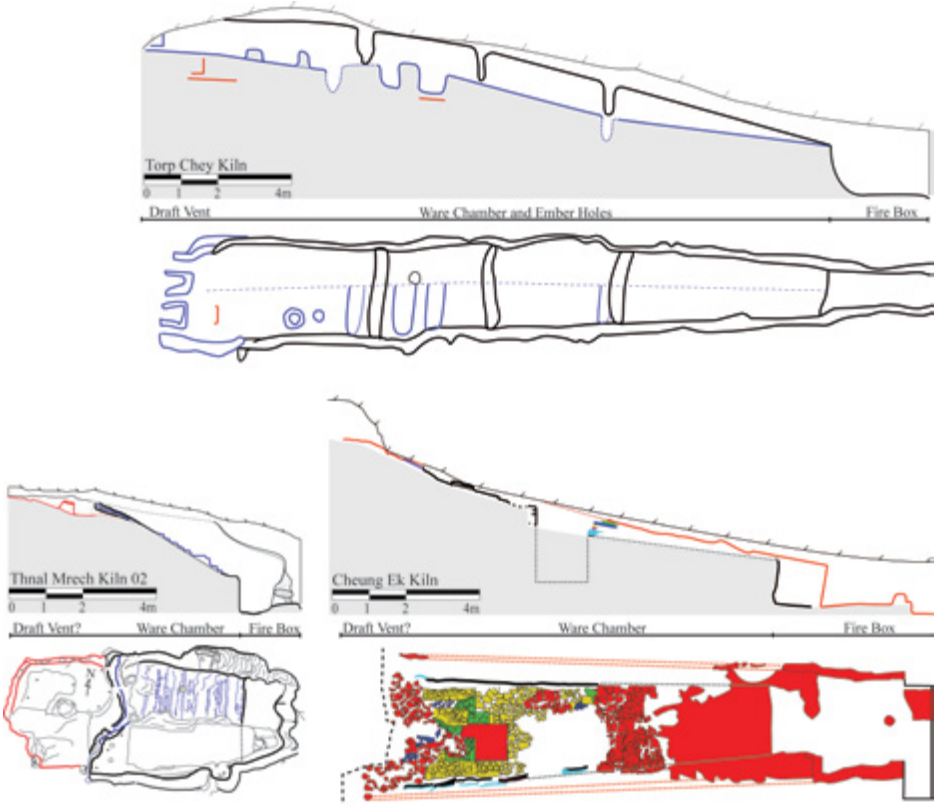


Figure 2. Thnal Mrech kiln 02, Cheung Ek kiln 17, and Torp Chey kiln: examples of crossdraft kilns: kiln slope and plan view of vent, chamber, and firebox. Images by APSARA Ceramic Team.

2013b: 231-249). This paper summarizes general characteristic aspects of Khmer stoneware production technology in Greater Angkor *versus* Buriram, discusses the development of kiln technology during the Angkor period, and identifies regional differences in the Khmer stonewares across the Khmer Empire.

General characteristics of the Greater Angkor and Buriram stoneware traditions

Two basic characteristics distinguish stoneware assemblages from Greater Angkor from those from Buriram: the range of vessel shapes produced and the firing technology. Potters in Greater Angkor produced a wider variety of stonewares through time than did Buriram potters. The ceramic classification system used for these comparative studies is based on a system developed to analyze materials from the TMK and BK sites (Miksic *et al.* 2009: 10-13; Chhay Rachna *et al.* 2009: 5, 2010: 9), incorporating the results of radiometric and relative dating to aid in our understanding of the wide range of Khmer stoneware production patterns (Aoyagi and Sasaki 2007: 141; Tabata 2008: 71; Miksic *et al.* 2009: 8-9; Hirooka *et al.* 2009: 57, 2011: 78; Desbat 2011: 26-27; Chhay Rachna *et al.* 2013b: 233; Ea Darith 2015: 88). Figure 3 combines a summary of kiln morphological characteristics with chronological information to illustrate that the fire box dimensions increased through time, as did the degree of floor slope.

Figures 4 and 5 illustrate Khmer stoneware vessel form classification, based on the Thnal Mrech Kiln (TMK) and Bangkong Kiln (BK) classification (Miksic *et al.* 2009: 10-13; Chhay Rachna *et al.* 2009: 5, 2010: 9). This classification uses *emic* ceramic categories (Khmer terms) to group them according to function, including: *Kpoeurng Sratob Chek* for roof tiles, small containers (including *Danlap* for round covered box, *Kotth* for conical-cylindrical box, *Khuoch* for bottle, *Ak kambor* for lime-paste pot, *Chan* for bowl or plate), and large containers (including *Krala* for jar, *Phoeng and Peang* for basin, *Ka-am* for long-necked water storage container).

Name	Complete kiln Structure		Fire box dimensions			Degree of floor slope	Chronology of kilns Century (AD) by used OxCal v4. & Archaeomanetic
	length	width	length	width	high		600 700 800 900 1000 1100 1200 1300 1400
BK 6A	>4.00	2.20	1.10	1.40	0.60	25%	
BK 6B	>5.00	2.00	1.20	1.20	0.75	90%	Archaeomagnetic
BK 15	---	---	1.35	1.75	>0.75	---	
BK 16	---	---	---	1.30	0.60	---	
TK B1	>4.75	2.75	1.00	2.00	0.75	<69%	
TK B4	>6.50	2.00	<1.50	2.00	1.10	<46%	
TK A6	>6.75	2.80	1.50	2.00	1.50	47%	
TMK 01a	<5.00	2.00	---	---	---	---	
TMK 01b	>3.50	1.40	1.00	1.30	0.90	76%	
TMK 02a	<7.50	2.90	1.00!	2.30!	1.00!	39%	
TMK 02b	>5.20	3.00	1.00	2.30	1.00	58%	
KPK B1	6.65	2.25	1.25	1.30	1.20	38%	
SK A11	> 6.00	2.50	1.60	2.00	1.00	39%	
CEK 17a	>11.60	2.75	>1.30	1.80	1.18	14%	
CEK 17b	15.40	3.70	2.90	2.60	1.10	25%	
TCK	>21.45	<2.80	>3.00	1.00	1.35	<28%	
CSK	18	3.10	>3.50	<2.00	---	<16%	
Buriram kilns	15.00!	2.00!	2.00!	---	---	---	

Figure 3. Excavated and dated Khmer stoneware kiln morphology and dates; by APSARA Ceramic Team.

Khmer potters used several techniques to decorate their vessels, including incised or freehand decorations, modelling and molding. The most common decoration involves horizontal incising (Chhay Rachna *et al.* 2013a: 181-182). This technique produces a variety of horizontal incisions and bands of various widths and textures, and frequently occurs on pedestal-base vessels, and on pot lids, shoulders and necks. Vertical or diagonal incised or impressed lines occasionally supplement the horizontal incising designs (*ibid.*: 186)

Buriram ceramics, including both glazed and unglazed stoneware, were produced in a limited range of shapes compared to those produced in the Greater Angkor kilns. Some Buriram kiln sites produced more green glazed wares than brown glazed, while other sites produced both brown and green glazed wares. Still other sites produced more unglazed wares than glazed wares (Natthaphat *et al.* 1995: 234). Buriram stoneware vessels have been found in the following forms: pumpkin boxes, bird-shaped boxes, animal figurines, kendi jars, dishes, bowl, bowl-shaped lamps, elongated water vessels with elaborate lids, gourd-shaped water vessels, and jars. Decorations include incised or freehand designs, modelling, and molding. Many different patterns have been documented in Buriram stoneware freehand decoration; some of the more notable examples include wavy lines, zig-zag lines, and 'X' designs (*ibid.*; Rooney 1984: 42-47; Srisuchat and Srisuchat 1989: 52-55; Chhay Rachna *et al.* 2013b: 237).

Greater Angkor and Buriram potters both used the wheel, coiling, modelling, and molding to produce their stonewares (Chhay Rachna *et al.* 2013a: 181-186, 2013b: 236). One important distinction between the two traditions is that small Buriram containers exhibit cord scars that suggest either throwing off the hump, or a lack of basal smoothing. That no cord scars have been observed on small Angkorian containers could suggest a different throwing technology, or an additional production step (base smoothing). Greater Angkorian potters frequently incised a potter's mark, while Buriram potters did not (Chhay Rachna *et al.* 2013b: 236). Some vessel shapes are unique to each of the traditions. For example, the Greater Angkor repertoire includes a conical-cylindrical box (*kotth*) and long-necked water storage containers (*ka-am*); conversely, the Buriram stoneware assemblage includes both pedestaled jars and anthropomorphic/human figurine shapes (Figure 6).

Angkor and Buriram potters both used modelling to decorate/produce lid knobs on small container lids in the shape of a lotus flower or Chan fruit (Diospyros decandra), and to produce animal figures (Chhay Rachna *et al.* 2013a: 186-187). Angkorian potters produced more varieties of these modeled lids than did those at Buriram. In addition, Buriram potters added a small hole to their container lids (Figure 7), while Angkorian potters did not (Chhay Rachna *et al.* 2013b: 236).

Angkorian and Buriram potters used the same range of decorative techniques on their stonewares but varied in their freehand decorations. The typical Buriram patterns include wavy lines, zig-zag lines, and 'X' design, as noted above. Angkorian potters incised at least seven different designs on their container lids, including a stamen, a star, a saw tooth, a Chan flower (*Diospyros decandra*), another floral shape, a lotus leaf, and lotus petal shapes (Figures 8 and 9) (Chhay Rachna *et al.* 2013a: 186). The Angkorian potters at the Torp Chey kiln site used or copied the decoration of wavy lines, zig-zag lines, and 'X' from Buriram's potters to decorate their pots, but with a few combinations of their own (Figures 9 and 10) (Chhay Rachna *et al.* 2013b: 237).

Some differences also characterize the crossdraft kiln structures that Angkorian and Buriram potters used, including how they loaded their kilns. Angkorian potters used three special kiln-stacking devices:

Figure 4. Khmer stoneware vessel form classification based on Thnal Mrech Kiln 2 and Bangkong kiln 15. Photos: APSARA Ceramic Team.

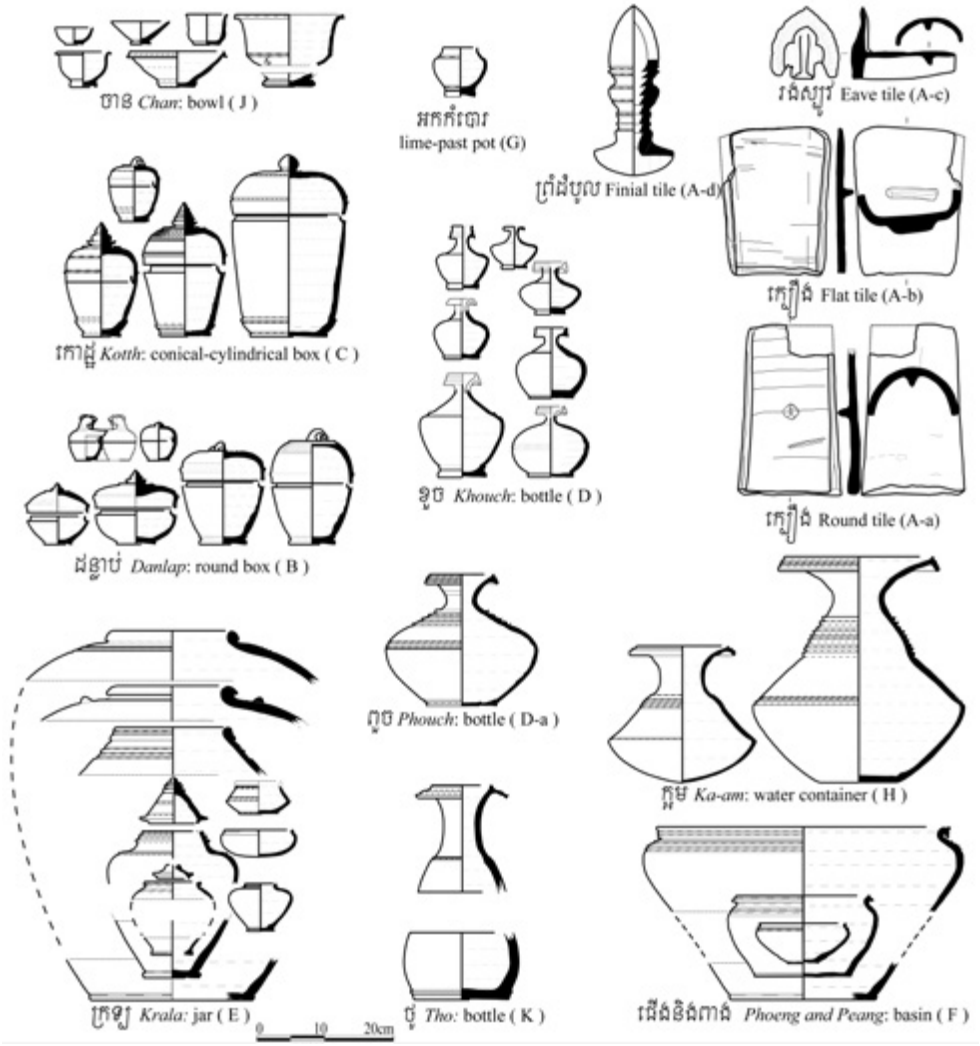


Figure 5. Angkorian stoneware classification system, based on Thnal Mrech Kilns and Bangkong kilns. Drawings by APSARA Ceramic Team.

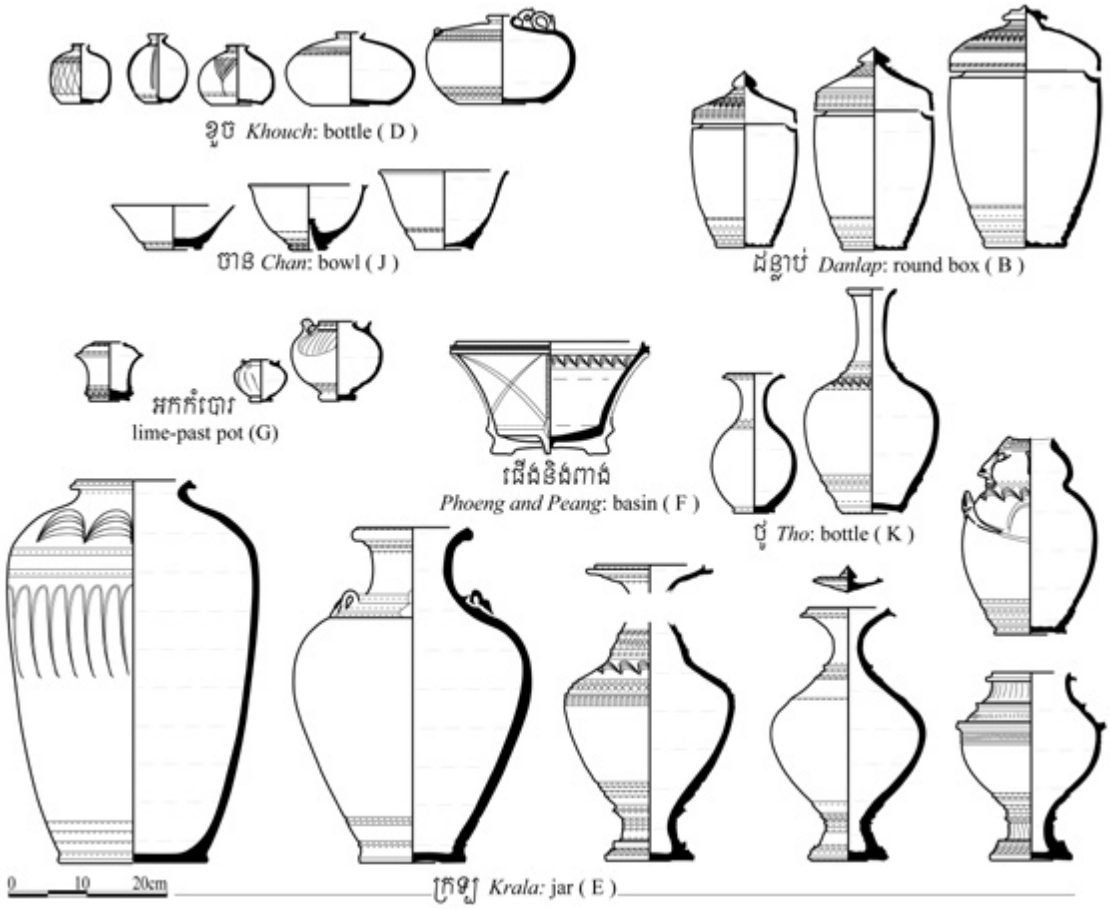


Figure 6. Buriram glazed stoneware vessel form classification. Drawings by APSARA Ceramic Team, based on images from Mourer (1986).

Figure 7. Contrasting manufacturing techniques in Greater Angkor versus *Buriram stonewares: base and lid treatments, based on Thnal Mrech kiln artifacts and Buriram artifacts found in Angkor occupation sites. Photos: APSARA Ceramic Team.*

(1) hand-rolled sausage-like coils that held and separated small vessels (e.g. *danlap*, *kotth*) and their lids (seen at TMK); (2) semi-cylindrical brick-shaped supports used to stand on the inclining floor; and (3) hand-shaped clay applied to interior surfaces of large vessels so potters could stack smaller vessels inside them. Figure 11 illustrates examples of kiln-stacking devices from some recently excavated kilns in Greater Angkor (e.g. Thnal Mrech, Sorsei and Thmor Chul). Potters used a variety of strategies: sometimes they put one piece of clay on the inner base of large vessels; more frequently they used two to four pieces of clay at key points inside the vessel (Chhay Rachna *et al.* 2013a: 192-193). Buriram potters preferred small clay balls or pallets and may also have placed multiple small clay balls in the interiors of small containers to stack many bowls on top of each other in a systematic fashion (Chhay Rachna *et al.* 2013b: 238-240).

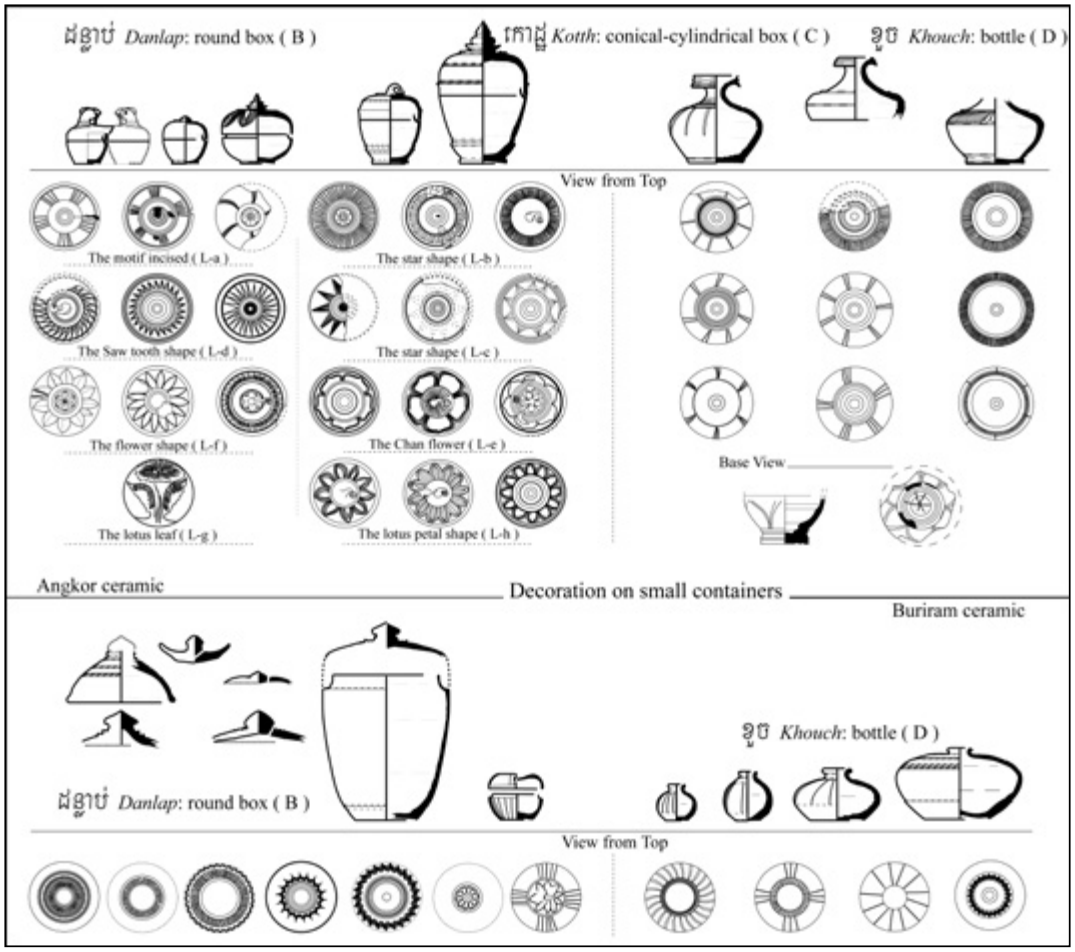


Figure 8. Decorative variability in small containers in Greater Angkor versus *Buriram stoneware, based on Thnal Mrech kiln artifacts and Buriram artifacts found in Angkor occupation sites. Drawings by APSARA Ceramic Team.*

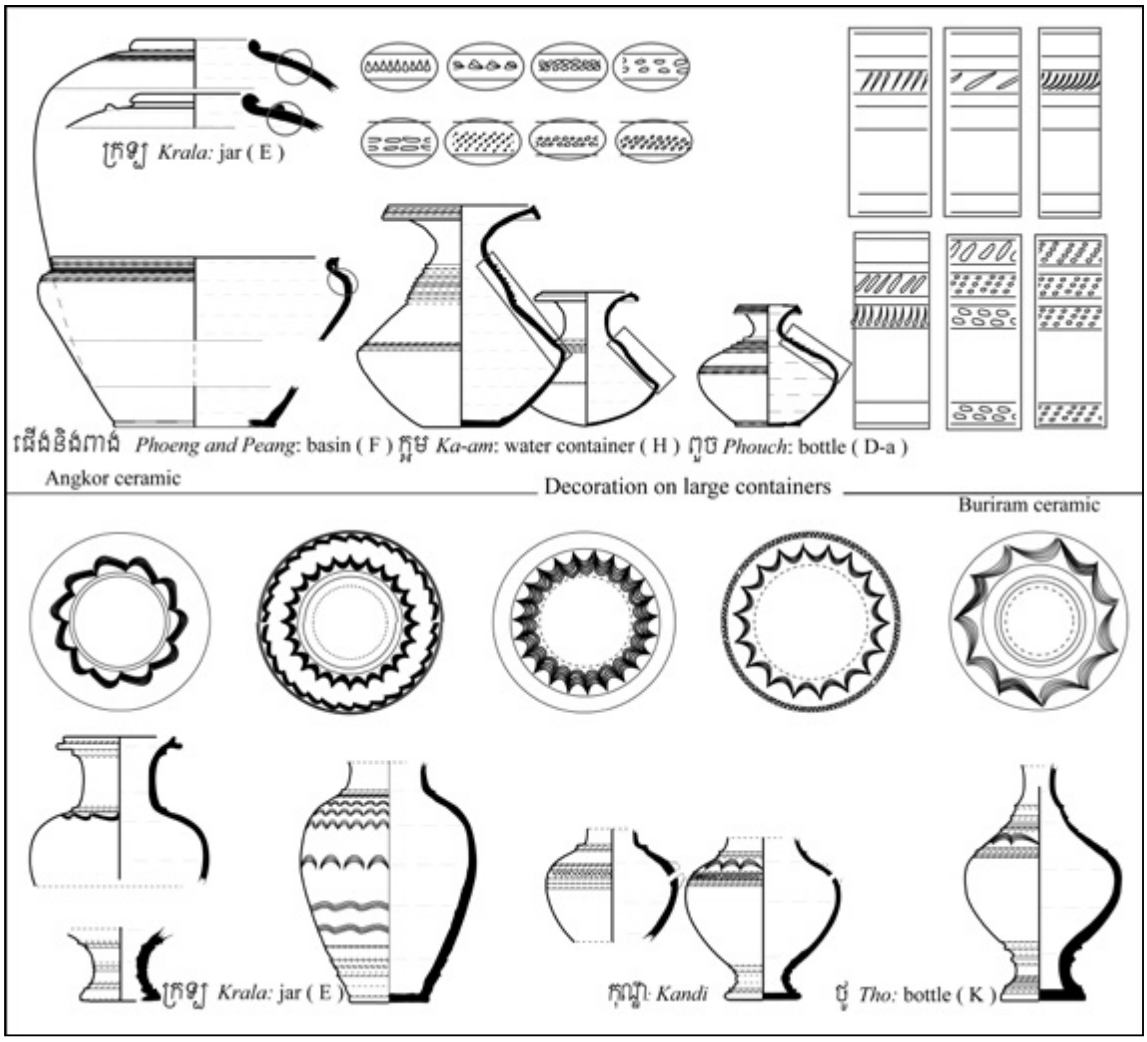


Figure 9. Decorative variability in large stoneware containers in Angkor versus *Buriram, based on Bangkong kiln artifacts and Buriram artifacts found in Angkor occupation sites. Drawings by APSARA Ceramic Team.*

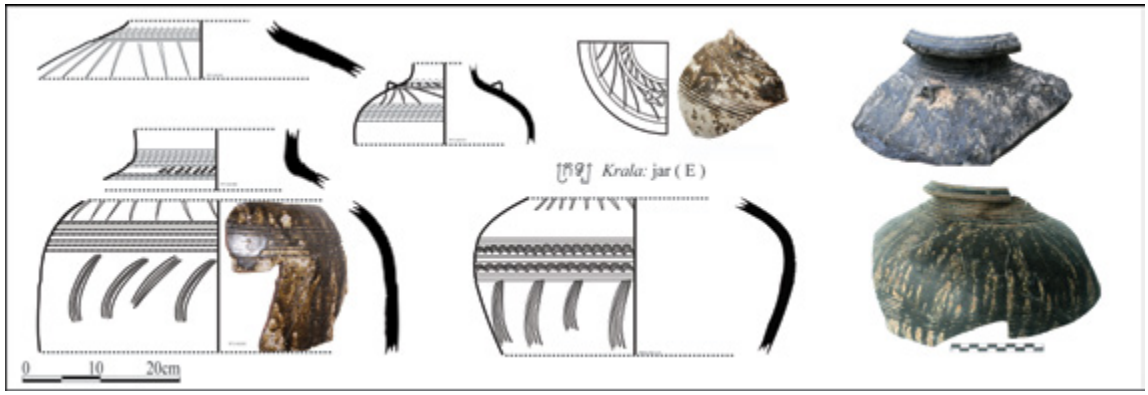


Figure 10. Kiln-specific jar decorations from Greater Angkor region 'Torp Chey examples', based on Torp Chey artifacts found in Angkor occupation sites. Images by APSARA Ceramic Team.

Figure 11. Examples of kiln-stacking devices from excavated Greater Angkor kilns and evidence for use of clay objects in kilns. Photos: APSARA Ceramic Team.

Conclusions

Our understanding of Khmer stoneware production has expanded considerably after two decades of field- and lab-based research on stoneware kiln sites and their products. We now believe that Khmer stoneware production in the Greater Angkor region began by the early ninth century CE and may have continued past the fourteenth century CE. Additional radiometric dates are needed to confirm that Buriram kiln production began at nearly the same time as at the kilns in Greater Angkor. The Buriram kilns clearly operated between the eleventh and thirteenth centuries, based on Buriram ceramics recovered from well-dated contexts in Greater Angkor. What remains unclear is whether production began earlier – but involved more restricted distributional networks and did not include Angkor – in Buriram. Angkor and Buriram stoneware, though variable in some respects, comprise part of a single Khmer stoneware tradition. It was nearly impossible to distinguish Khmer glazed brownwares from these two different regions. The 2011 excavations of the Angkorian Torp Chey Kiln (TCK) have produced brown-glazed ware vessels whose shape and firing techniques contrast with those found in Buriram, but TCK's decoration is very similar to Buriram pottery.

Acknowledgments

This case study would not have been accomplished without support from Bun Narith, Director of APSARA authority, Ros Borath, Vice Director of APSARA authority, and Mao Lao, Head of the Department of Conservation of Monuments in Angkor Park and Preventive Archaeology. We extend our gratitude to John Miksic (National University of Singapore), Heng Piphal (University of Hawai'i-Manoa), and Chhay Visoth (National Museum), who supported the Thnal Mrech kiln excavation plan. Many thanks to Roland Fletcher and Miriam Stark, director and co-director of the Greater Angkor Project (GAP), who provided

the great opportunity for us to collaborate with GAP, and produced great information from the third GAP fieldwork season. Many thanks also to the Greater Angkor Project, Friends of Khmer Culture, and the Fourteenth International Conference of the European Association of Southeast Asian Archaeologists (EurASEAA), who supported our work and organized the great EurASEAA14 Conference.

New data on the chronology of Khmer stonewares

Armand Desbat

For more than thirty years the chronology of Khmer stoneware has been based on the pioneering work of B.P. Groslier, who published the first synthesis on its evolution in 1981. His chronology was widely based on his excavations at different sites, especially the royal palace of Angkor and the burial site of Srah Srang, but his dating was based on Chinese ceramics, and above all on the chronology of the monuments, based mainly on epigraphy and to a lesser extent on the history of art. The discovery of several potters' workshops around Angkor and other regions, as well as developments in stratigraphic excavation, allow us today to be more precise concerning some dates, and to revise some hypotheses concerning the start of the decline of Khmer stoneware. If the beginning of Khmer stoneware seems to be confirmed during the ninth century AD, it appears that, in opposition to previous hypotheses, production did not decline after the twelfth century, but that there was a revival during the thirteenth century. The study of consumption sites shows that the end of local potters' workshops in the Angkor region does not signify the decline of ceramic production, but the development of new production centers which supplied Angkor until the beginning of the fifteenth century.

Résumé: Depuis plus de trente ans, la chronologie des grès khmers repose sur le travail pionnier de B.-Ph. Groslier à qui l'on doit la première synthèse sur l'évolution de la production des grès khmers, parue en 1981. Sa chronologie reposait largement sur les fouilles qu'il avait réalisées sur divers sites, en particulier le palais royal d'Angkor Thom, et la nécropole de Srah Srang, mais les datations proposées s'appuyaient sur la céramique chinoise et surtout sur la chronologie des monuments, fondée en premier lieu sur l'épigraphie et dans une moindre mesure sur l'histoire de l'art. La découverte de plusieurs ateliers de potiers, autour d'Angkor ou dans d'autres régions ainsi que le développement depuis une quinzaine d'années des fouilles stratigraphiques permettent aujourd'hui de préciser certaines datations et de réviser des hypothèses concernant l'apparition et le déclin des grès khmers. Si le début de la production des grès khmers au IXe siècle se trouve confirmé, il apparaît qu'elle ne périclite pas après le XIIe siècle mais connaît un renouveau au XIIIe siècle. L'étude des sites de consommation démontre que l'arrêt des ateliers situés autour d'Angkor ne signifie pas le déclin de la production céramique, mais se traduit au contraire par le développement de nouveaux centres de production qui alimentent désormais Angkor jusqu'à l'orée du XVe siècle.

Introduction

For more than thirty years, the chronology of Khmer stoneware has been based on Groslier's (1981) pioneering synthesis of its evolution. Groslier distinguished seven periods in the chronology of Khmer stoneware from the late ninth to thirteenth centuries AD, when he thought the empire declined. His chronology was widely based on his excavations, notably at the Royal Palace of Angkor, where he distinguished four phases, and at the burial site of Srah Srang (Groslier 1957, 1964; Courbin 1988), where several hundred vases were unearthed. His proposed dates were based on Chinese ceramics – of which he had a good knowledge – and the chronology of the monuments, which was supported at that time by epigraphy and to a lesser extent by art history.

Inscriptions presenting building or consecration dates of temples were considered for a long time the best evidence to date ceramics retrieved from monuments (e.g. Rooney 2000). This can be deceptive, however, as it may happen that a site was occupied before the temple dates. In addition, the date of the construction of a monument does not provide evidence for its duration of use or potential reuse (e.g. Groslier 1981: 13). For instance, at Roluos recent studies and excavations have shown that the founding of the Bakong Temple, previously believed to date from the late ninth century AD based on inscriptions from Indravarman I, must date back one hundred years earlier (Penny *et al.* 2006). And excavations of the North Library of the Bayon, usually attributed to Jayavarman VII and dated from the beginning of the thirteenth century, revealed that the platform of the Library was probably raised

during the fourteenth century (Naho 2000: 207). Similarly, new research has proved that several sites at Roluos established in the ninth century were reoccupied during the twelfth and thirteenth centuries (Pottier *et al.* 2007). Another example comes from ongoing excavations at the West Mebon. At this temple, traditionally dated to the eleventh century, most of the ceramics unearthed date to the thirteenth century. In general, we can conclude that the date of a temple does not provide accurate dating for ceramics found within it.

One consequence of dating based on epigraphy or architecture is that it has been difficult to date ceramics between the middle of the thirteenth century and the fall of Angkor around AD 1430, because 'not a single monument in stone was then raised' (Groslier 1981: 13). A hypothesis stemming from the difficulty in recognizing ceramics from the thirteenth century, was that the decline of Khmer ceramics resulted from the Cham sacking of Angkor in AD 1177, also associated with a 'veritable collapse of art' (*ibid.*: 30). This assumption could explain the lack of ceramics interpreted to date from the thirteenth to fourteenth centuries (and see Rooney 1990: 5). However, new studies have shown that ceramic production was still strong after the twelfth century (see below).

Another criticism we can make of Groslier's model is that he undervalued the role of provincial kilns, especially the Buriram kilns, even after he visited them (e.g. Groslier 1981: 31). Brown (2006) reported in an oral presentation that 'Groslier did not include the Buriram kilns in his Khmer chronology... When he did have a chance later to see Buriram products he claimed...that they were not represented at any of his sites at Angkor. The Buriram kilns, he believed, served local provincial needs, not imperial metropolitan needs'. Groslier called green-glazed items from Buriram 'kulen ware', despite their different origins and dating, which led to confusion in the chronology of green-glazed stoneware (Groslier 1981: 23; e.g. a covered box from Buriram (no.1 in the catalogue, p. 70) is dated 'late ninth century, Preah Ko style'). Groslier's chronology was therefore based on several arguments that can be disputed, and the limits of this chronology have been pointed out by some scholars (e.g. Cort 2000: 108). It would not be surprising if data coming from new excavations or new research methods could shatter the chronology established thirty years ago.

Data from archaeology

The discovery of several potters' workshops around Angkor and other regions, along with the development of stratigraphic excavation methods and the use of approaches such as radiocarbon dating, allow us today to be more precise about the chronology of some sites, and to distance our understanding from a chronology based only on epigraphy or monumental architecture. At the same time, the discovery of several new shipwrecks, and excavations of graves and kilns in China have given more certainty to the dating of Chinese wares, which remain the best basis for dating. Many new data are now available, and they allow us to put forth new hypotheses regarding the onset and decline of Khmer stoneware.

The Kulen type of stoneware

Regarding Kulen stoneware, we now know of three more kiln sites producing the same wares as the kilns of Anlong Thom at Phnom Kulen: the Tani, Sar Sei, and Khnar Po kilns (Aoyagi and Sasaki 2007; Tabata 2005, 2008; Ea Darith 2009) (Figure 1). Some of these have been excavated, giving new data on the beginning and evolution of stoneware production.

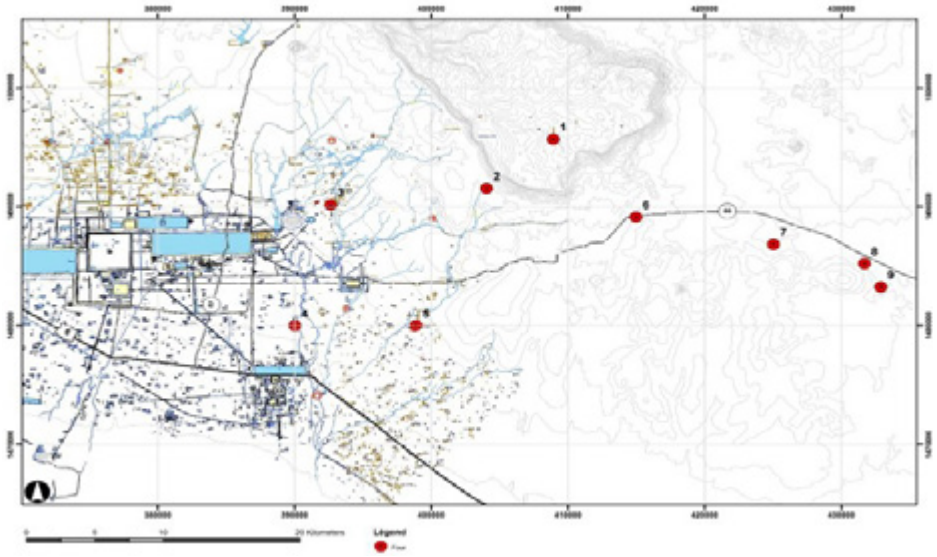


Figure 1. Map of the stoneware kiln sites around Angkor. 1: TMK=Tnal Mrech (Anlong Thom); 2: SAS=Sar Sei; 3: Tani; 4: BKG=Bankong; 5: KNP=Khnar Po 6: TLK=Teuk Lech; 7: TCI=Torp Chei; 8: MBI=Muoyroy Bey; 9: MBN=Muoyroy Buon. Map by EFEO/GAP/Jica.

The start of Khmer stoneware production has been traditionally dated to the late ninth century AD, linked with the founding of the capital of Jayavarman II at Phnom Kulen, where some kilns have been known for a long time (Aymonier 1901). Excavations at Thnal Mrech, near Anlong Thom, did not find any kilns from the ninth century, nor any evidence of older stoneware production. The two kilns excavated gave several radiocarbon dates: TMK 01 was dated to AD 903-1015 (Tabata 2008), while TMK 02 gave five dates: AD 1016-1157, 1022-1166, 1025-1208, 1027-1211, and 1031-1215 (Miksic *et al.* 2009; Miksik and Chhay Rachna 2010). The dating of the second kiln led the excavators to conclude that: 'TMK 02 was in use during a period of approximately fifty years, in the early eleventh century CE' (Miksic and Chhay Rachna 2010: 9). The radiocarbon data offer different dates for the two kilns, which may suggest production lasting more than one century at the Thnal Mrech workshop, although these are not the oldest kilns known at present; the discovery of kilns probably dating from the ninth century on the south dyke of Khnar Po (Desbat *et al.* 2010), the oldest yet researched, has provided us with an early phase of production.

The earliest products are characterized by being small pieces, very well wheel-thrown, with small moldings on their bases (Figures 2-4). The clay is fine, the glaze very thin, pale yellow or ivory, and often does not stick very well to the sherds. The forms are very close to those seen in contemporaneous Chinese wares, on which they were modelled. For example, some copies of Tang box lids, or small jars (*Wannian*) have been found (Figures 5-6). I believe that the influence of Chinese ceramics at the beginnings of Khmer stoneware production is clear, although some scholars disagree with this hypothesis (e.g. Tabata 2010: 104).

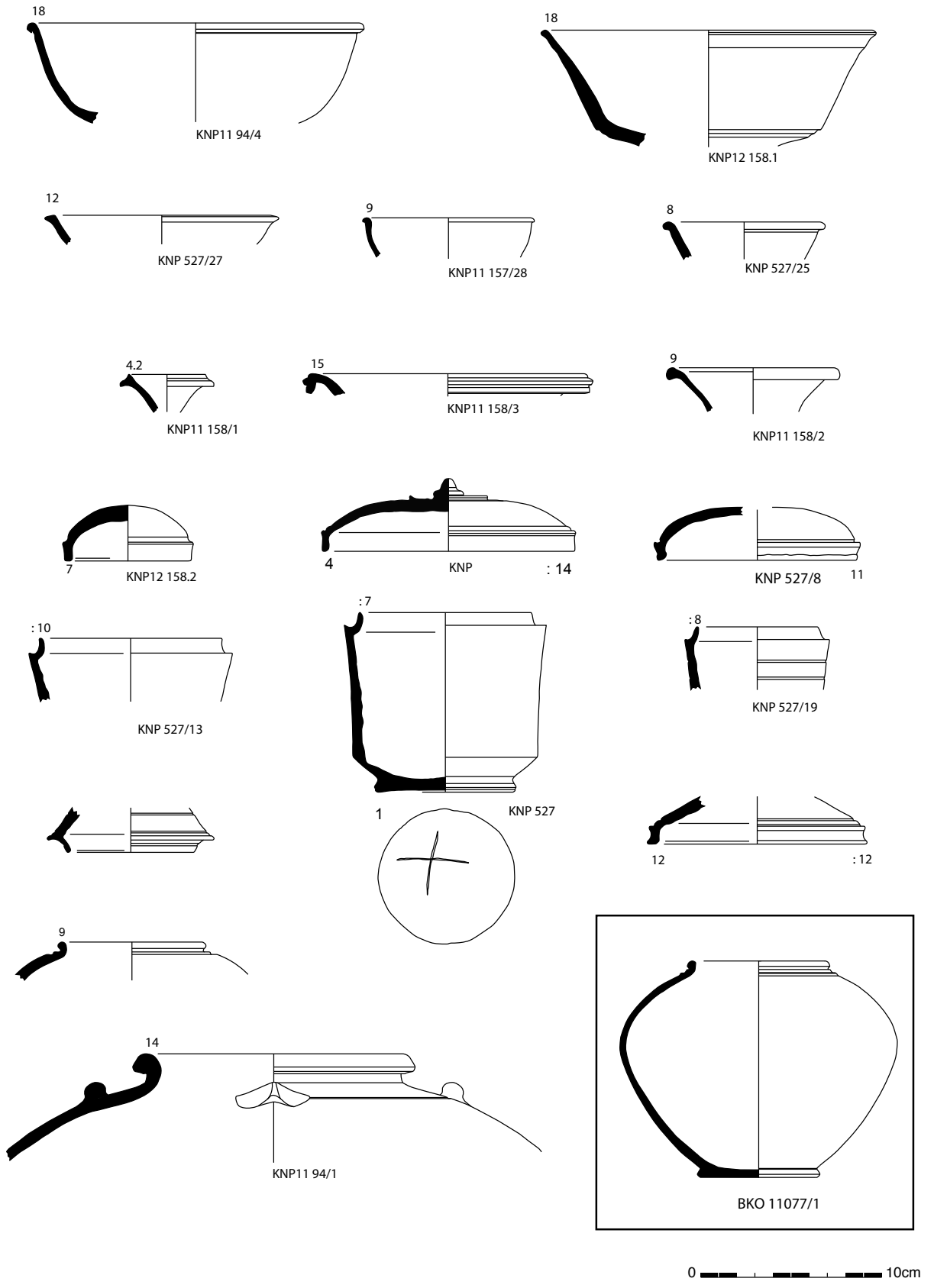


Figure 2. Kilns of Khnar Po, bowls, flagons and pots. Drawings by Hong Ranet.

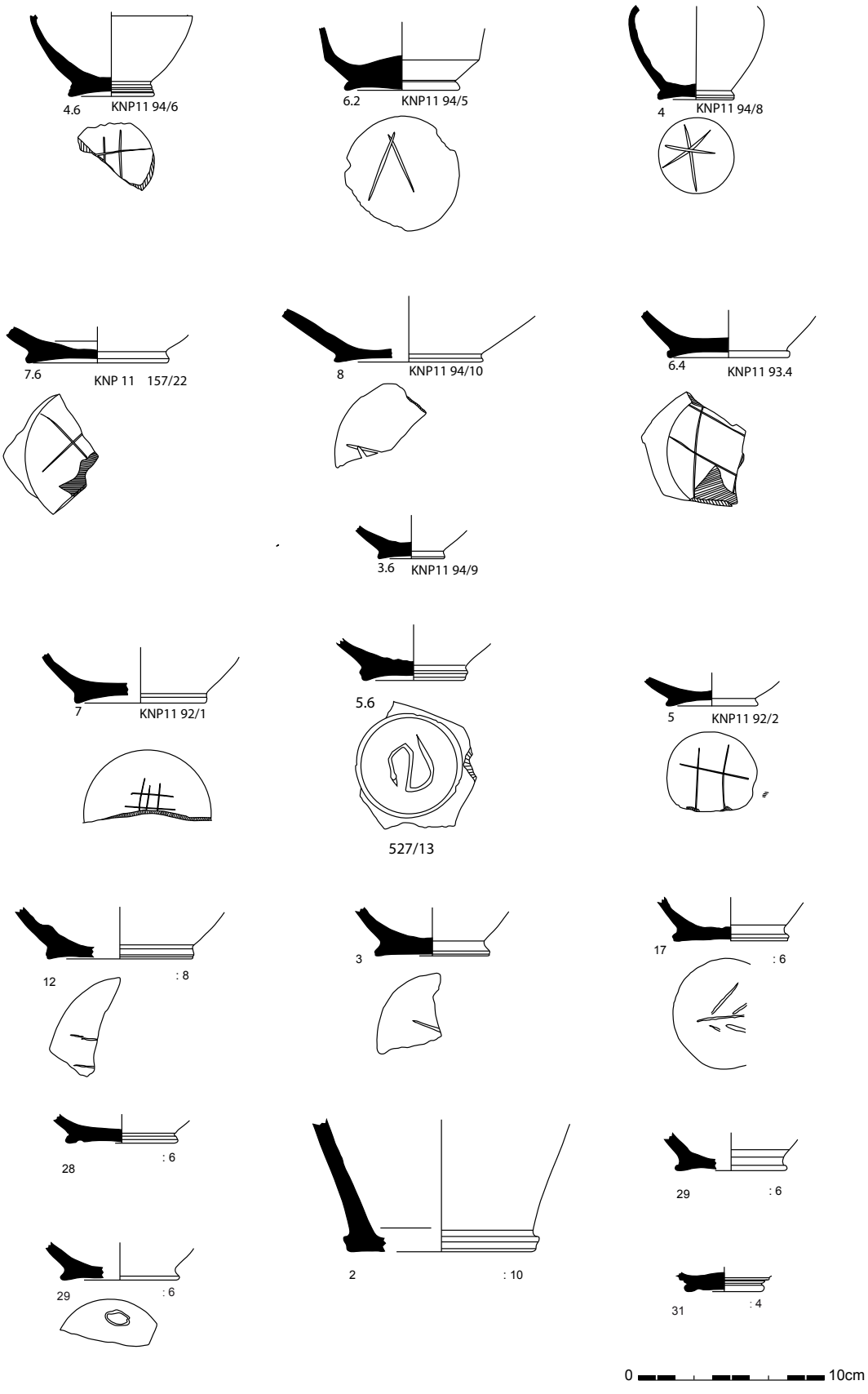


Figure 3. Kilns of Khnar Po, bases. Drawings by Hong Ranet.

Figure 4. Lid of box; compare with the Tang box in Figure 6. Photo: A. Desbat.

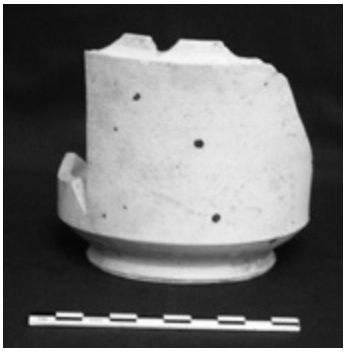


Figure 5. Box (urn) from new kilns of Khnar Po. Photo: A. Desbat.

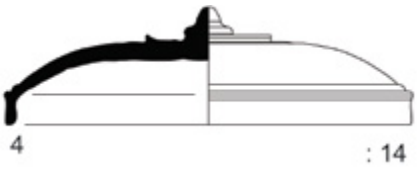
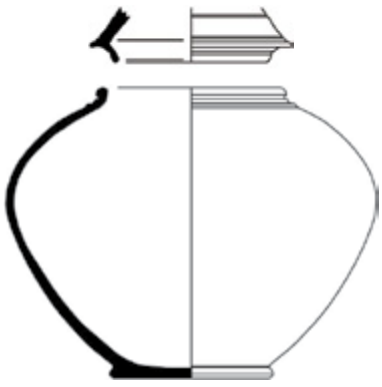
Angkorian stonewares	**Chinese models**
	 Guandong ware (Brown 1988)
	 Tang box (Watson 1984)
	 Wannian Jar (Watson 1984)

Figure 6. Comparison between Khmer and Chinese stonewares. Images on left by A. Desbat and Hong Ranet.

The end of production of Kulen stoneware must be more accurately dated. It is certain that diffusion of the wares ceased in the late twelfth century; they have not been found on the site of Prasat Ta Muong, established during the reign of Jayavarman VII (Pottier and Chhem 2010). But it is possible that the kilns ceased to exist earlier, in the late eleventh or early twelfth century. It seems that the last items produced at Kulen were brown-glazed stonewares (Figure 7), contrary to Groslier's (1981) beliefs that these were not produced at the Phnom Kulen kiln site. These brown stonewares were made with clay richer in iron than that used in green stoneware (Thirion-Merle *et al.* 2019). This production was less numerous than that of green or yellow wares and was not widely circulated outside the Phnom Kulen area. At Poeung Tbal, a site at Phnom Kulen excavated by J.-B. Chevance (2013) with the Phnom Kulen Program, brown-glazed stoneware accounted for ten percent of all glazed stoneware, and even for sixteen percent in one test pit (Figure 8). Most of the lids have a small button similar to some Buriram type lids, and their decoration is only made of incised lines. We do not know whether the appearance of brown-glazed items resulted from difficulty in sourcing white clay or was a consequence of Buriram influence.

Figure 7. Brown-glazed lids from Anlong Thom kilns. Photo: A. Desbat.

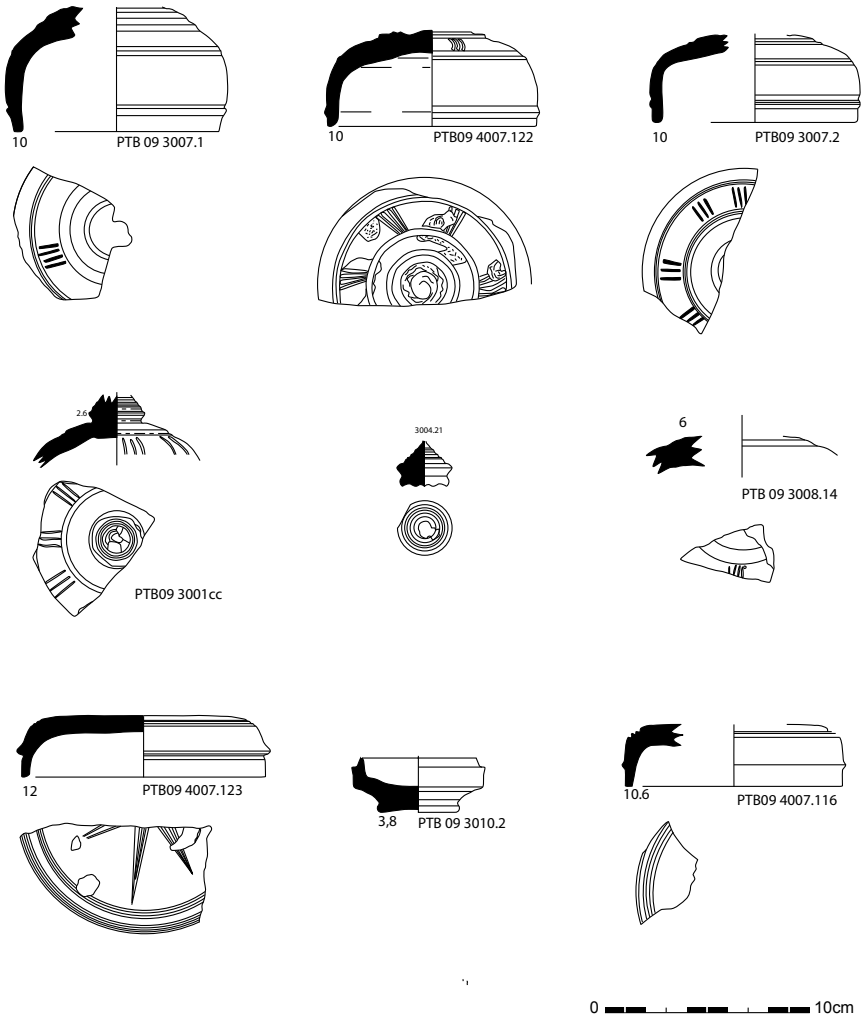


Figure 8. Brown-glazed lids from the excavations of Poeung Tbal, on the Phnom Kulen. Drawings by Hong Ranet.

The kilns of Torp Chey

The kilns of Torp Chey were discovered in 2007 during surveys along the eastern road leading to the great Preah Khan (Hendrickson 2008), *c.* fifteen kilometers to the east of Beng Mealea. These five kilns produced large black-glazed jars. One kiln of Torp Chey was excavated in 2011 by the APSARA National Authority (Hein 2012), and later surveys also by APSARA discovered other kilns to the east: Muoyroy Bey and Muoyroy Buon (Ea Darith 2009, 2010), presenting similar production (Figures 9-10). It is impossible to distinguish with chemical analyses the wares from the different kiln sites, which is the reason they are all called 'Torp Chey type' stonewares (Desbat *et al.* 2012).

The location of these kilns near two temples dating from the twelfth century has suggested that they were producing during this period (Hendrickson 2008: 56). The products of these kilns can be found at almost all Angkorian sites, especially at the end of the thirteenth into the fourteenth century, and it seems that production did not begin before the late twelfth century. The Torp Chey type stonewares also resemble the final group of Khmer stonewares that Groslier (1981: 30) dated to the late thirteenth century, which include 'stoneware with very thick runny and marbly glaze...from black to dark green with sulphur-yellow marbling'.

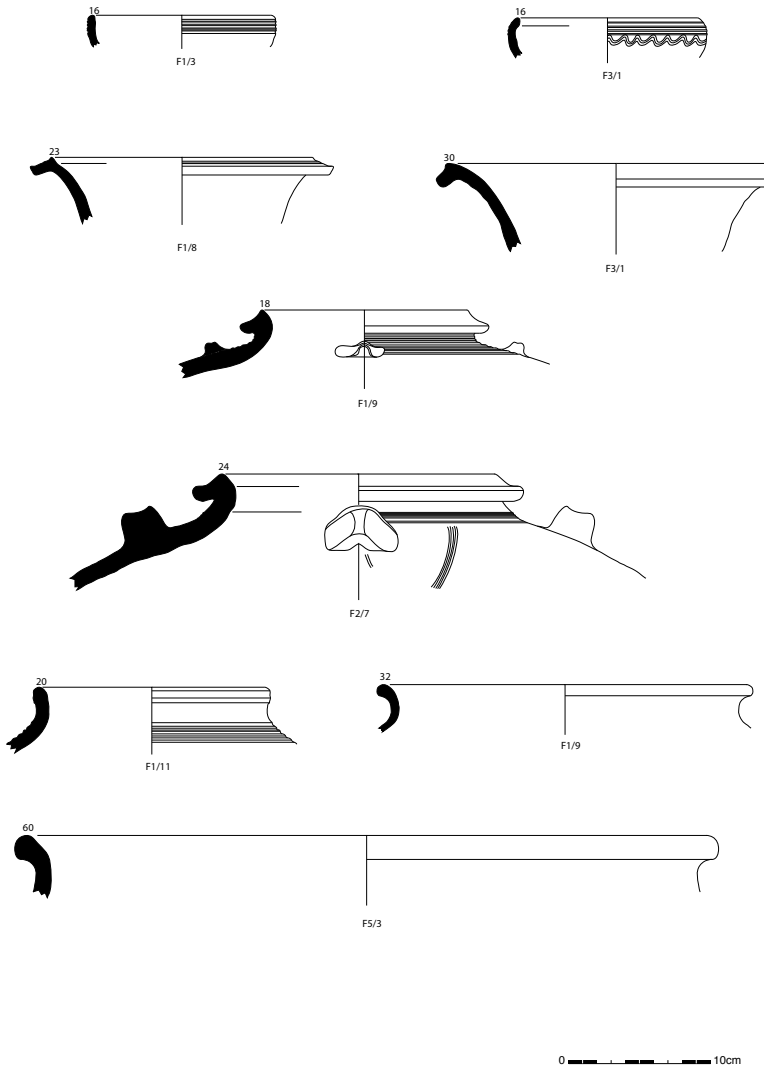


Figure 9. Brown-glazed stonewares from the kilns of Torp Chey. Drawings by Hong Ranet.

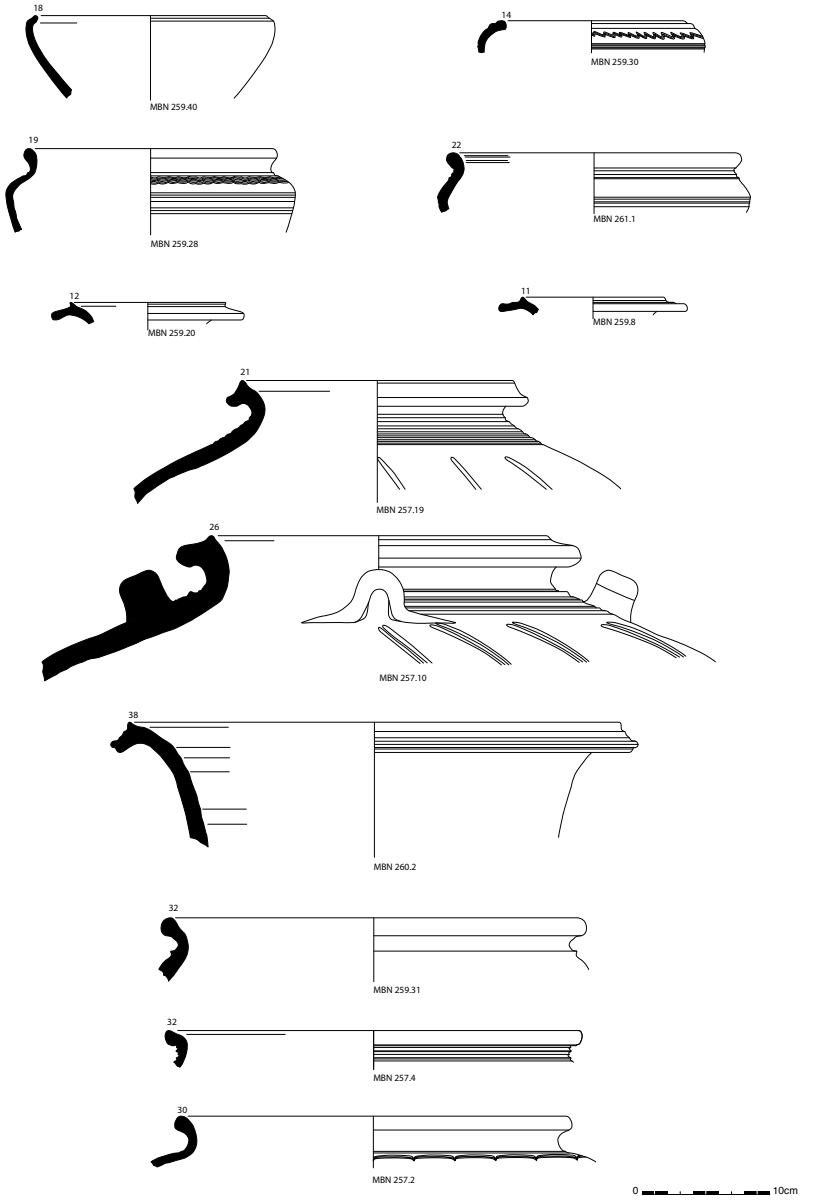


Figure 10. Brown-glazed stonewares from the kilns of Mouyroi Bourn kilns. Drawings by Hong Ranet.

The provincial kilns: Buriram

The existence of pottery workshops in the province of Buriram has been known since the 1970s (Childress 1976; Childress and Brown 1978). More than two hundred kilns have been located, but few are excavated (Khwanyen 1985; Natthaphat 1990), and their chronology remains vague. Some radiocarbon dating done at one kiln site suggests that production took place there in the ninth to twelfth centuries AD (Srisuchat and Srisuchat 1989). Despite the starting date of AD 740-770 being mentioned (*ibid.*), two sigma range calibration of the radiocarbon ages provided in that paper suggest that such an early date is misleading and highly improbable (3%). For instance: BP 1160±50 = [cal. AD 718: cal AD 743] 0.030911 _ [cal AD 769: cal AD 990] 0.969089; BP 1030±50 = [cal AD 892: cal AD 1052] 0.846867 _ [cal AD 1080: cal AD 1129] 0.112568 _ [cal AD 1132: cal AD 1153] 0.040565; and BP 610±70 = [cal AD 1277: cal AD 1430] 1 (after intcal09.14c; Reimer *et al.* 2009). For other scholars the start of production should be dated to the eleventh century, when most of the Buriram temples were built (e.g. Brown 1988: 53).

It is certain that these kilns widely supplied Angkor, contrary to Groslier's suggestion, and that the majority of vases from Srah Srang came from Buriram kilns. New excavations have shown that the production of these kilns was still extensive in the thirteenth and maybe the early fourteenth century. The Buriram stonewares, mostly found in thirteenth century layers, include a lot of brown-glazed vessels, but also bowls and plates with green glaze (Figures 11-13). For instance, the excavations of the Prasat Ta Muong Hospital, founded by Jayavarman VII at the end of the twelfth century, produced 4076 sherds of ceramics, of which 668 (16.6%) were from Buriram, 269 green-glazed (6.6%) and 399 brown-glazed (10%). This proves that the green glaze did not disappear after the twelfth century, as argued by Rooney (1984: 28), and that the date of AD 1177 does not mean the end of the Buriram kilns.

Figure 11. Green-glazed bowl from Buriram. Photo: A. Desbat.

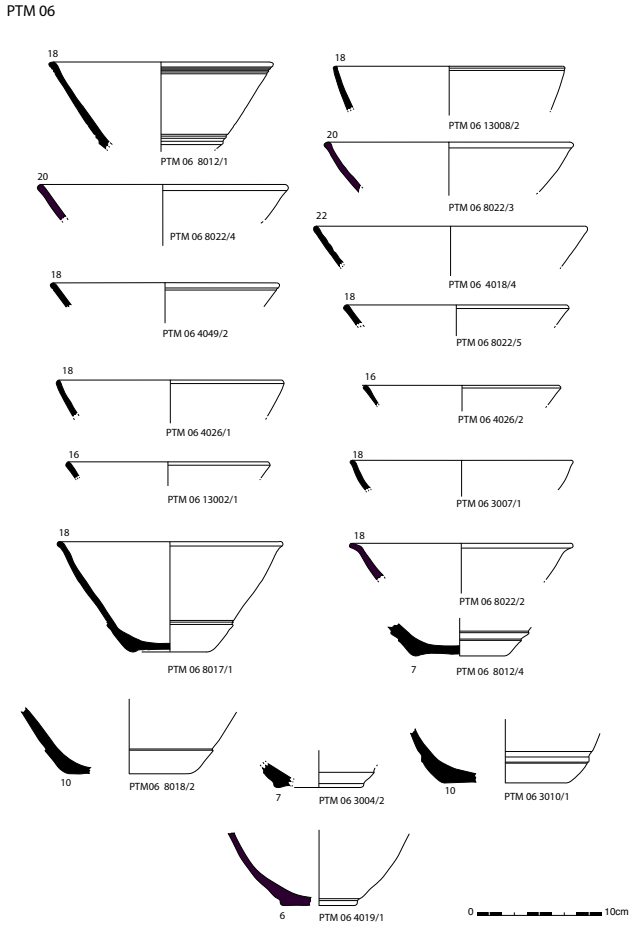


Figure 12. Green-glazed bowls from the Prasat Ta Muong Hospital. Drawings by Hong Ranet.

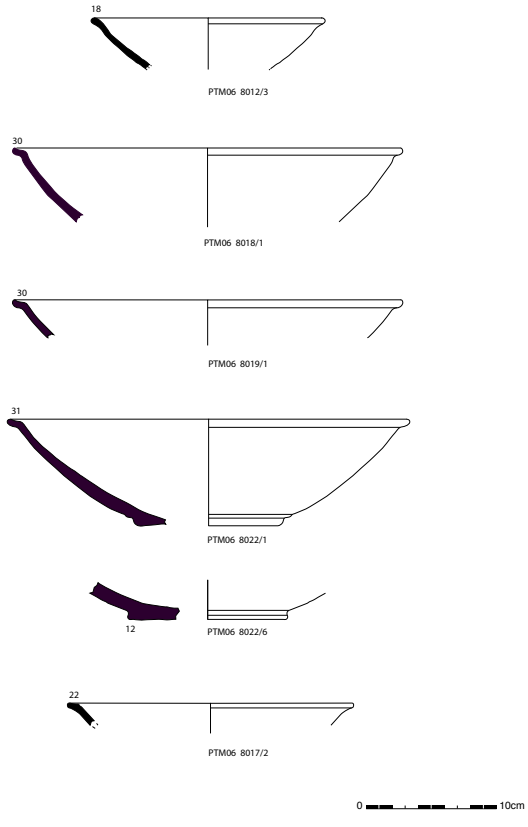


Figure 13. Green-glazed plates from the Prasat Ta Muong Hospital. Drawings by Hong Ranet.

Other kilns producing the same products were discovered along the North Road from Angkor to Phimai, Oddar Meanchey Province, during surveys undertaken by the Living Angkor Road Project, as well as in Banteay Meanchey Province (Ea Darith 2009). Unfortunately, all of these kilns were looted or destroyed, and only scarce data have been retrieved. It is currently impossible to distinguish the products of these kilns from those of Buriram.

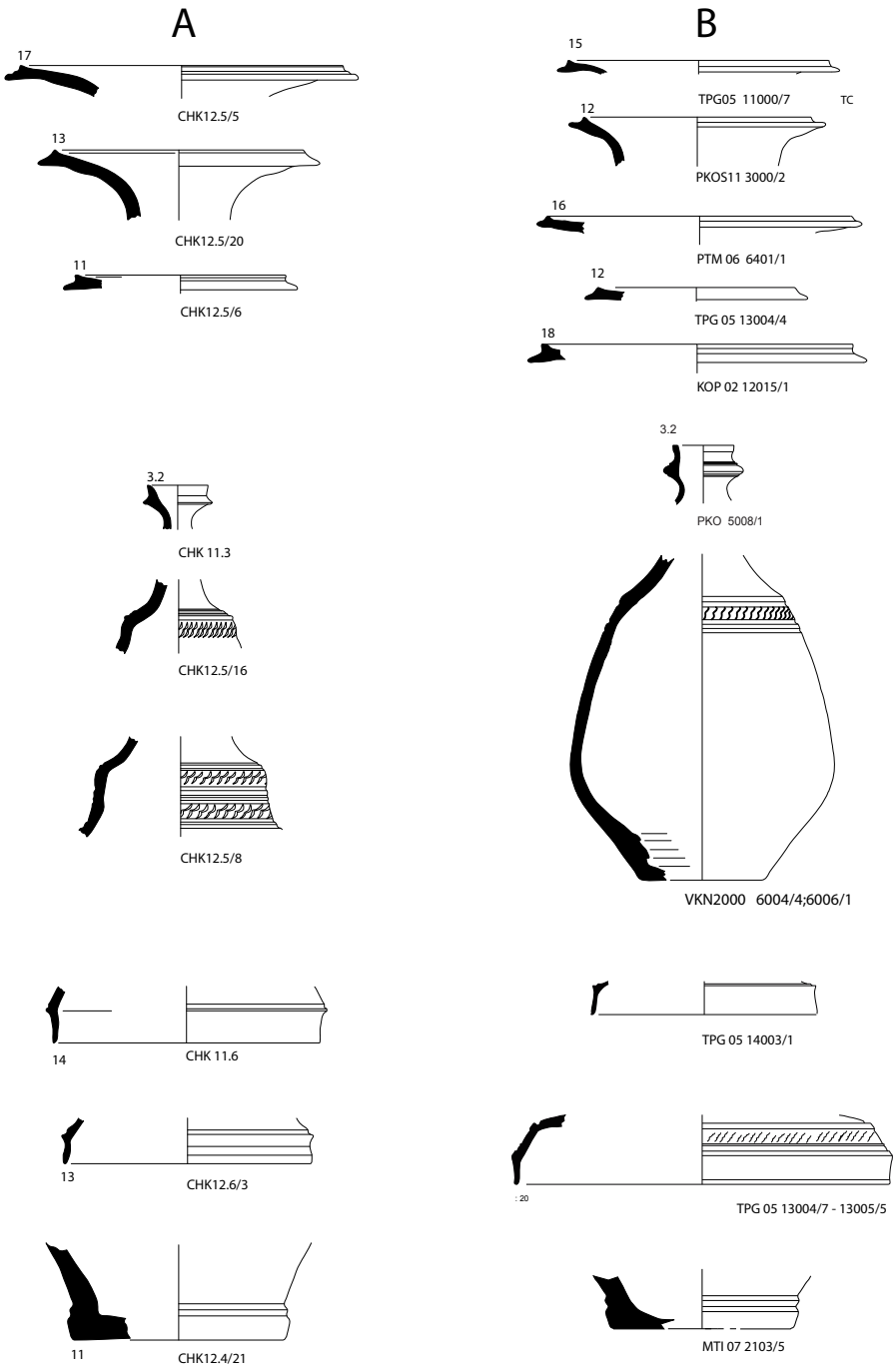


Figure 14. Some types of stoneware from the Choeung Ek kilns (A) and Angkorian sites (B): TPG=Trapeang Phong; PKOS=Prasat Konap; PTM=Prasat Ta Muong; KOP=Kok Phnoeu; PKO=Prah Ko; VKN=Vat Knat; MTI=Prei Monti. Drawings by Hong Ranet.

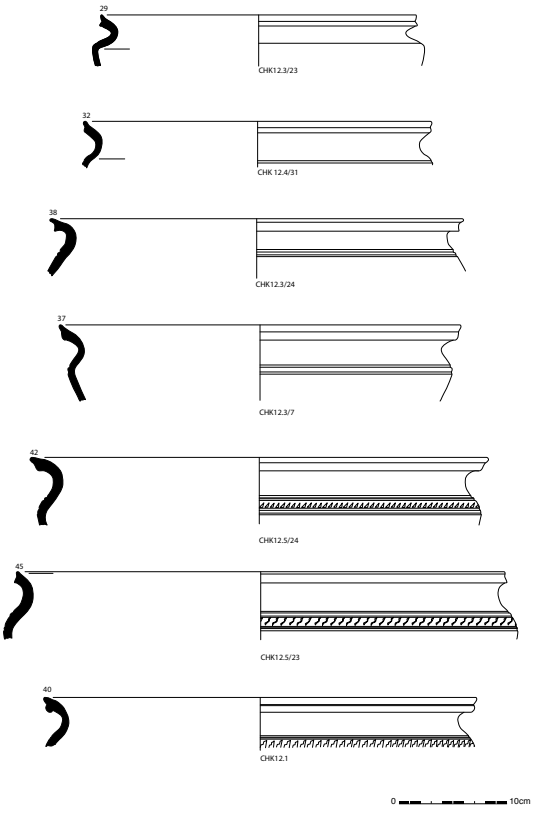


Figure 15. Basins from the Choeung Ek kilns. Drawings by Hong Ranet and Yorn Sothearith.

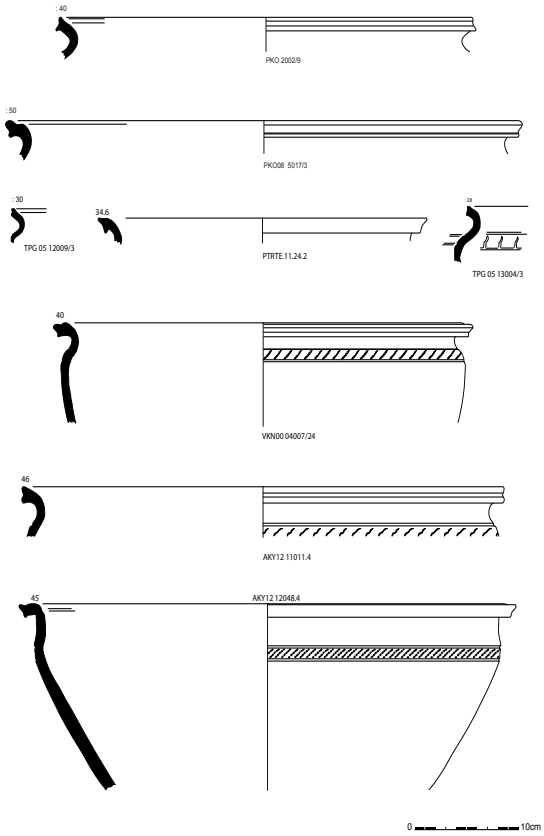


Figure 16. Basins from Choeung Ek found in Angkorian excavations: PKO=Preah Ko; TPG=Trapeang Phong; PTRTE=Prasat Trapeang Ropou; VKN=Vat Knat; Aky=Ak Yum. Drawings by Hong Ranet and Yorn Sothearith.

The provincial kilns: Choeung Ek

The kilns of Choeung Ek were discovered in 2000 (Phon Kaseka 2002, 2007), five kilometers south of Phnom Penh. Close to sixty kilns were located in a three kilometer stretch from north to south; these kilns produced stoneware and earthenware. Their location near Phnom Penh, but also not far from Funan remains, has suggested that they may date either from pre-Angkorian times or, on the contrary, from the fifteenth century AD, after the relocation of the capital from Angkor to Phnom Penh in the early fifteenth century (Ea Darith 2010: 101). The study of ceramics from several sites in Angkor, however, shows that Choeung Ek wares were exported to Angkor from the twelfth to fourteenth centuries (Figures 14-16).

Ceramics from Choeung Ek have been found on the many sites excavated for the MAFKATA program (Mission Archéologique Franco-Khmère sur l'Aménagement du Territoire Angkorien): Aak Yum, Prei Khmeng, Kôk Phnoeu, Kôk Ta Sien and Vat Khnat (West Baray), Bakong, Trapeang Phong, Prei Monti and Preah Kô (Roluos). They were also found at Prasat Ta Muong, a hospital chapel to the west of Angkor Thom, excavated by the Angkor Medieval Hospitals Archaeological Project (Pottier and Chhem 2010), on all the sites excavated by the Yaçodaraçrama program (Soutif and Estève 2010-2017), and even at Phnom Kulen (Chevance 2013). Together this represents more than 50,000 ceramic sherds, excluding roof tiles. The duration of these wares after the fall of Angkor is possible but not yet proven.

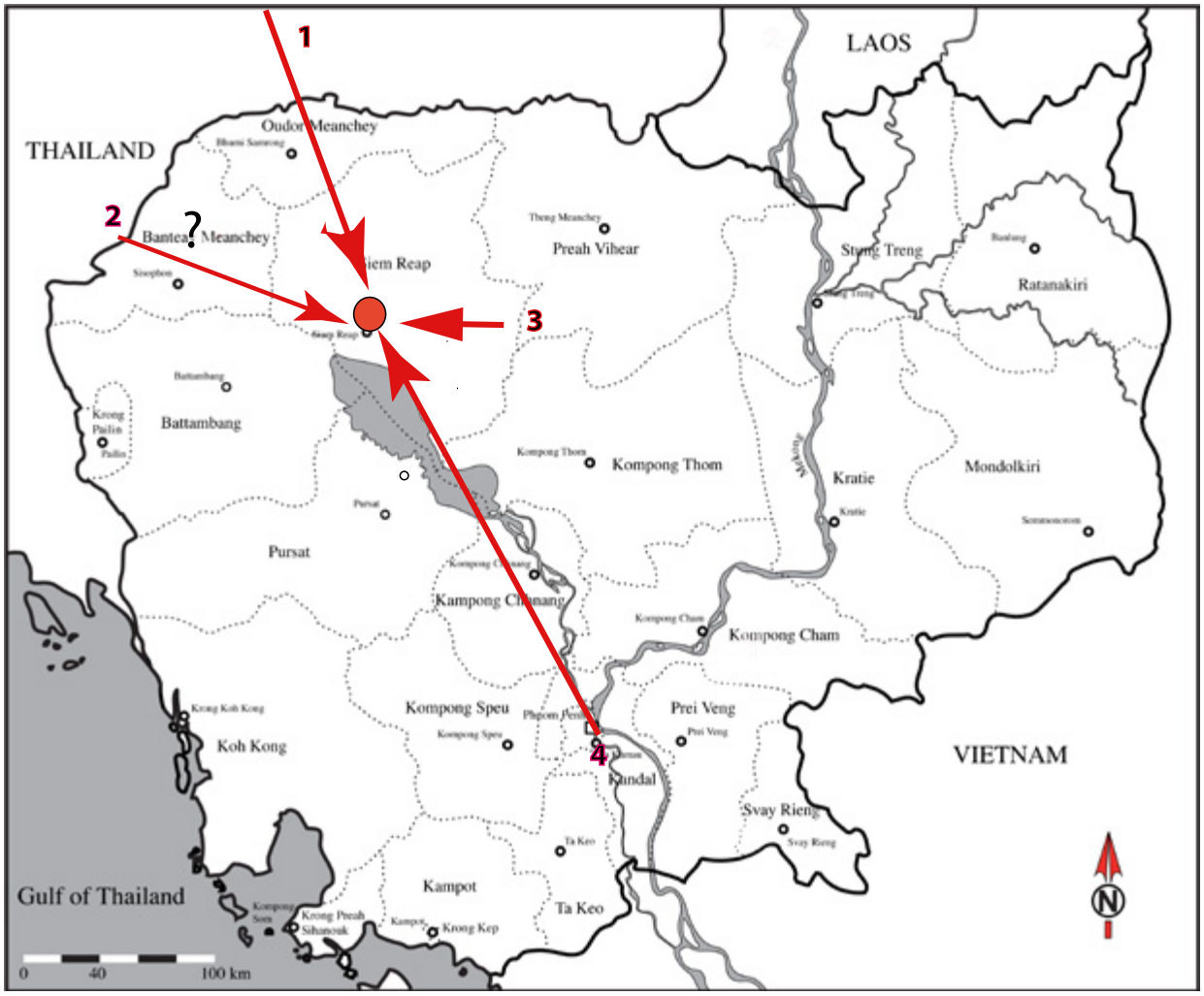


Figure 17. Different sources of ceramics supplying Angkor from the twelfth to fifteenth centuries AD: 1. Buriram and Udar Meanchey kilns; 2. Banteay Meanchey kilns; 3. group of Torp Chei kilns; 4. Choeung Ek kilns. Map by D. Soutif and A. Desbat.

Conclusion

The beginning of Khmer stoneware may date to the ninth century AD, and it appears that, contrary to previous assumptions, its production was not in decline after the twelfth century, but that a revival occurred in the thirteenth century. Study of consumption sites has shown that the end of the workshops presently known near Angkor (the dating of which is still not accurate), does not represent the decline of ceramic production, but conversely the development of new production centers in the provinces, such as Buriram, and perhaps sites in Oddar Meanchey, Banteay Meanchey and Kandal provinces (the kilns of Choeung Ek), which supplied Angkor until the beginning of the fifteenth century (Figure 17).

Acknowledgements

Thank you to Phon Kaseka (Royal Academy of Cambodia), Christophe Pottier (EFEO, MAFKATA), Dominique Soutif and Julia Estève (EFEO, Yaçodharâçrama), Jean-Baptiste Chevance (Phnom Kulen Program), Pierre Bâty (INRAP, Aéroport de Siem Reap) and Pascal Royère (EFEO, West Mebon Project).

The conical rollers of Ban Non Wat, northeastern Thailand

Christina Sewall

Ban Non Wat is a well-stratified mounded site in northeastern Thailand. Excavations there have yielded thousands of artifacts and hundreds of burials dating throughout the Neolithic, Bronze and Iron Ages. Among the most regularly-occurring artifacts are earthenware objects which have been informally referred to as 'conical rollers'. These artifacts have not been reported from any other site, even those closest to Ban Non Wat. A formal analysis of their physical characteristics describes and defines conical rollers, explores their function, and analyzes their distribution across the site and stratigraphically, to identify patterns of association between conical rollers and other artifacts and features. They were also compared with potentially similar artifacts from other sites. Despite the analysis of distribution data and the construction of an initial typology characterizing their attributes, the function of conical rollers remains unknown.

Introduction

Ban Non Wat is a village in lower northeastern Thailand in the Non Sung district of Nakhon Ratchasima province. Located in the upper Mun River catchment, it sits within the floodplain upon one of many mounded archaeological sites surrounded by encircling earthworks that are concentrated in this region (Figure 1) (Higham and Kijngam 2009: 3). Excavations from 2002-2007 identified a cultural sequence of twelve phases, beginning with hunter-gatherers and followed by Neolithic, Bronze and Iron Age occupation dating between 1750 BC-AD 500 (Higham and Higham 2009: 137). The chronological framework established through interpretation of the stratigraphy and the mortuary record provides evidence for cultural developments that began with pioneer rice farmers and ended with the early foundations of the Kingdom of Angkor (*ibid.*: 139). It is within the context of the Bronze and Iron Ages that conical rollers are found. The number of conical rollers found thus far suggests they were commonly used. During the first phase of excavations, 1018 were recovered (Higham and Kijngam 2009: 248). After a second phase of excavation, a further 809 conical rollers were found by 2010 (N. Chang, unpublished database, personal communication, 2010). These make up the sample for this study.

The term 'conical roller' was chosen without any certain knowledge of their function. It was applied during the first phase of excavation at Ban Non Wat, because of the conical shape of the object's tip and the cordmarked patterns which seemed to bear a resemblance to the most simply-decorated clay rollers found at Ban Chiang in northeastern Thailand (Folan and Hyde 1980; C. Higham, personal communication, 2011). It is a misnomer, as they are neither conical nor rollers. However, the name has now entered the literature, and will be used in this paper.

Many other Bronze and Iron Age sites in the region have produced assemblages of artifacts similar to those found at Ban Non Wat. Burials containing large quantities of grave goods including pottery, jewelry, bronze, copper and iron tools, spindle whorls, shells and other offerings are commonly found. Material remains indicate that pottery production, smithing, casting and weaving were taking place at these sites (Higham 2002). Despite this, artifacts resembling conical rollers have never been reported from any other site in Southeast Asia. Ceramic cylinder seals and 'rollers' have been found at other prehistoric sites in northeast Thailand, such as Ban na Di and Ban Chiang (*ibid.*: 191), and at Lao Pako in Laos (Karlström 2000: 90), but none are directly comparable to the conical rollers found at Ban Non Wat in their physical form or decoration. However, they are both found in similar chronological contexts and it is possible that they share a similar function (Sewall 2011).

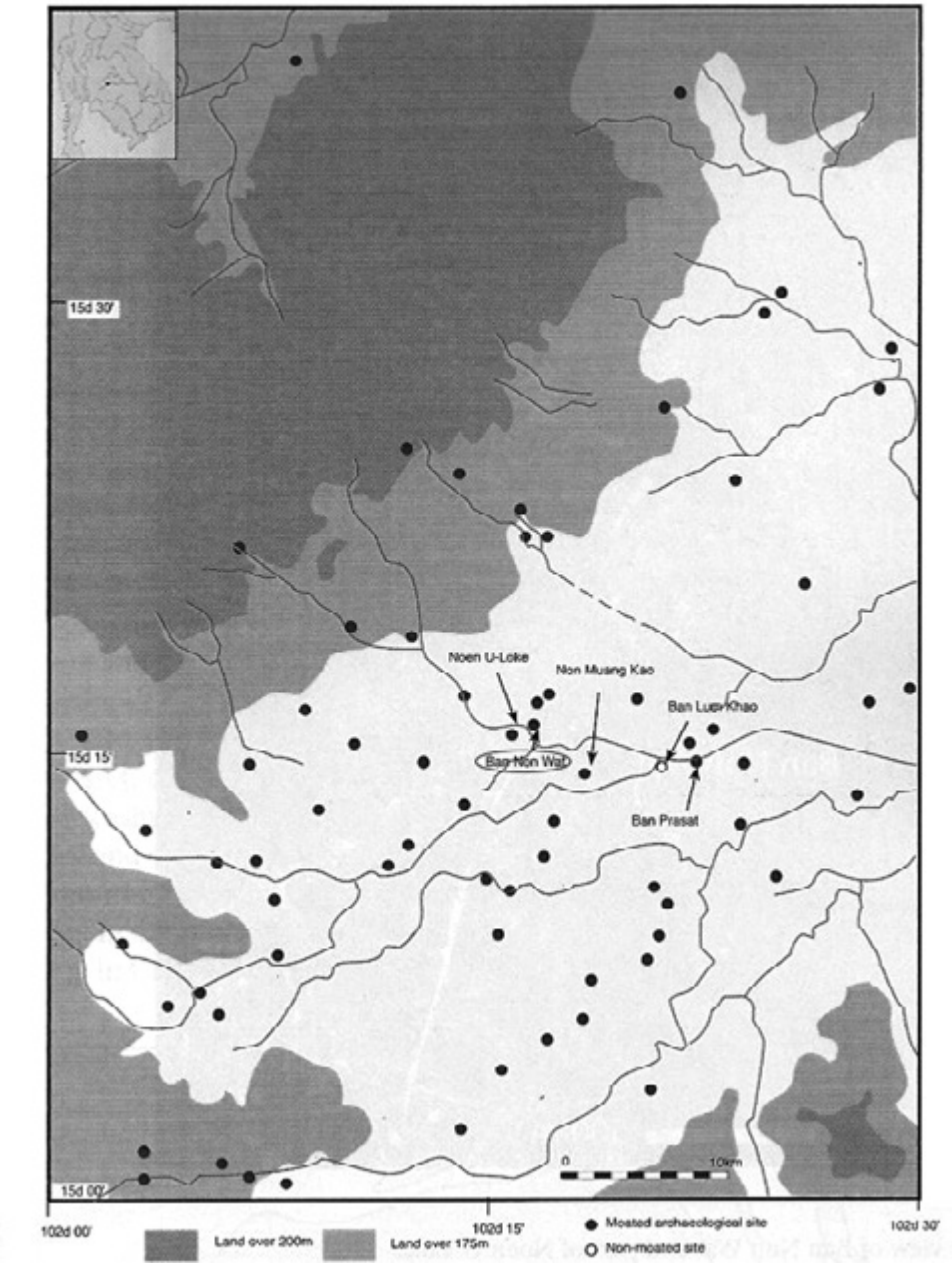


Figure 1. Map showing Mun River Valley prehistoric sites, including Ban Non Wat. After a map by Higham and Kijngam (2009: 3), reproduced with permission from C. Higham.

Conical rollers have a roughly arrow-shaped appearance and are characterized by a triangular or conical tip and a smaller attached handle or tail (Figure 2). The tip is the most commonly found portion. The lower portion of the tip is always incomplete, being more vulnerable to breakage because of the space between it and the inner portion of the tip/tail assembly. In addition to breakage, mild to moderate wear is common on the pointed end of the tip. In many cases the tail has broken off partially or completely. Hundreds of fragments have been found, most appearing to come from the tip (Sewall 2011). It appears that the two pieces were made separately and assembled before firing (Figure 3). In some cases, fingerprints are visible where small bits of clay were pushed in to solidify the connection.

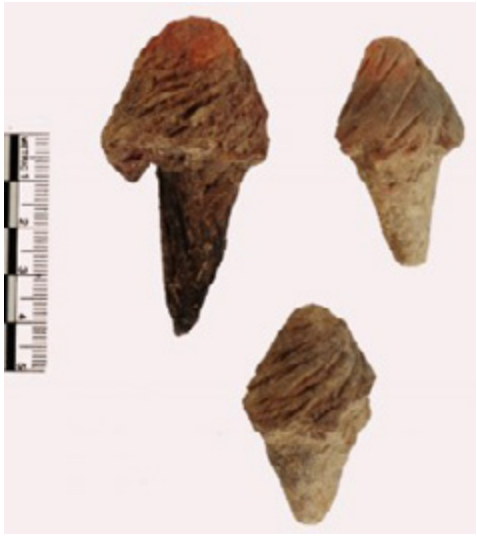


Figure 2. Photo of conical rollers. Photo: G. Stryker.

Conical rollers are made from coarse clay. Inclusions of laterite nodules, chaff, shell, and very small bits of clay, usually bright red in color, can be seen with a hand lens. The outer surface ranges in color from light and dark grey to buff, to red depending on firing temperature and degree of oxidation. The interior has a similar range of colors (Sewall 2011). These artifacts are decorated with impressions made by cordmarking in a spiral pattern. Several variations are present. Closely-spaced cordmarking is most common, but a widely-spaced pattern is frequently seen as well. Another style is characterized by a smooth surface with widely-spaced cordmarking made with a noticeably thinner cord. The impressions appear in a clockwise pattern diagonally on the tip. On the tail they may go in either direction. All conical rollers appear to have been constructed in a similar way with a standard form and style of decoration in mind, but each one has individual characteristics with regard to size, shape, texture and cordmarking, perhaps reflecting differences in the maker's skill and artistic ability, or variations necessary for its function (*ibid*.).

Figure 3. Photo showing connection between tip and tail. Photo: C. Sewall.

Samples and methods

The conical rollers examined in this study were excavated during three field seasons at Ban Non Wat (2007-2010; e.g. Higham and Kijngam 2009; Duke *et al.* 2010). The sample included all conical rollers from these years in order to examine the full range of variation within their physical attributes. A total of 237 conical rollers were classified as complete, tip, tail or half. An additional 555 fragments were studied. Data were collected on conical rollers from all excavation units in order to examine and interpret of the widest range of contexts within the site (Sewall 2011).

Each conical roller was described, drawn and photographed. A hand lens was used to examine the fabric and decoration. After examining and recording was completed, the information was entered into a database created for this study. The measurements taken include diameter of the tip, measured at one or more different points (-0.5, -1.0, -2.0, -3.0 centimeters down from the top where possible), overall length, tail length and length of the tip from top to edge, as well as relative density via displacement using a digital scale and a graduated beaker, from forty of the conical rollers, ten each from four site units (S400, G104, N100, and N96). Because the beaker did not have sufficiently specific gradations, the accuracy of the displacement measurement cannot be assured. However, the process was used consistently. This subset yielded results that were used for comparative purposes to reveal patterns that might indicate differences in the materials with which the conical rollers were made. The measurements were plotted to determine whether any trends were visible both across the site and within individual excavation units (Sewall 2011).

The conical rollers were counted using the principle of the minimum number of individuals (MNI) and by counting the number of individual specific pieces (NISP). To determine MNI, each artifact was first classified as belonging to one of five categories: tips, tails, halves, complete conical rollers or fragments (Sewall 2011). To be counted as a tip it had to contain more than half of the rounded top portion. Tails were counted if they had the complete end portion. Halves were tips which were at least 50% complete, but which did not have more than half the rounded top. Complete conical rollers had both a tip and a tail, using the previously described criteria. Any that did not meet the criteria of being a tip, a tail, a half or a complete artifact were classified as fragments. Calculation for the NISP total included each fragment, tip, tail and complete conical roller. The MNI total did not include any fragments (*ibid*.).

Because they are relatively unknown and have never been described in any publication, it was not possible to classify conical rollers based on a previously developed typology. An original typology was developed (Sewall 2011). Size, form and decoration were chosen as the most important attributes; relative density and amount of wear were also evaluated. Color, texture and composition were examined and recorded but not analyzed systematically. The systematic classification according to color types was not undertaken because of the tremendous variation, from grey to brown to red, often within one piece. Individual variation also prevented classification by texture or materials used (see below). Due to varying degrees of wear and breakage, differing numbers of conical rollers were available for each specific measurement and assessment (*ibid*.).

Classification by shape was problematic. Many conical rollers are arrow-shaped, especially complete ones and large tips. However, because of the amount of breakage along the lower edge of the tip, it is not clear if all of them were constructed with an arrow-shape or if some were shaped as a solid cone. For this study they were classified as arrow-shaped if the lower portion of the tip was clearly separated from the tail. Shape was also assessed by calculating the ratio of the diameter of the tip measured at two points (-0.5 and -2.0 centimeters down from the top). This was done to determine whether there was an observable pattern in the angle of the sides of the tip (Sewall 2011).

Decoration was observed with a hand lens and recorded for each tip, tail and complete conical roller, which were categorized as being cordmarked (closely- or widely-spaced, e.g. see Figure 10 below), cordmarked and slashed, slashed, or not clearly marked. Uncommon decorative attributes, such as burnishing or unusual positioning of decorative marks, were also recorded. The amount of wear on each tip and complete conical roller was observed using a hand lens and recorded in the database on a scale of 1-4 based on how minimal or severe the wear was (Sewall 2011).

Distribution patterns of conical rollers and associated artifacts and features, as well as data on the soil matrix where conical rollers were found was analyzed and interpreted using site records. The number

of conical rollers found within each unit and within each layer and spit was recorded and the data processed. A series of graphs and charts was produced to represent the proportions of conical rollers in each stratigraphic context (Sewall 2011). This was done using both MNI and NISP figures. A second series showed the changing proportions of conical rollers throughout the Neolithic, Bronze and Iron Ages. In this case the number of conical rollers within the volume of soil from each context within each excavation unit was calculated, based on site records. This allowed for differences in soil volumes between excavation units (*ibid*.).

The field database was used to assemble a record of artifacts found in the same contexts as conical rollers. Data were used to compare conical rollers to several other commonly associated artifacts. Graphs were created to analyze their distribution within each excavation unit. The percentage of conical rollers relative to all other artifacts was also calculated (Sewall 2011). The field database was incomplete for several units which were therefore not included in the analysis. The database was also used to compile a list of features found at the same layer and spit as conical rollers and to record each feature with which a conical roller was directly associated. Drawn plans and sections were used to examine features and soil changes associated with the majority of conical roller finds in unit S400 (*ibid*.).

Typology

It was not possible to do fabric analysis on this sample at the time due to lack of access to appropriate laboratory facilities. However, analysis of Bronze and Iron Age mortuary ceramics from Ban Non Wat using an electron microprobe identified temper materials, natural mineral inclusions, and clay matrix composition which suggested the ceramic wares were locally manufactured (Sarjeant 2008: 1). It is likely that conical rollers were made from local clays as well, based on the observed similarities in texture, inclusions, and color variations. Laterite nodules, small pieces of shell, and rounded fragments of red clay are the most common inclusions visible with a hand lens (Figure 4; Sewall 2011). The clay generally has a good deal of sand either added as temper or occurring naturally within the clay matrix. This gives most conical rollers a coarse texture. A small number of conical rollers are composed of clay that appears to be slightly finer; an even smaller number appear to have a much higher sand content than most (*ibid*.).

The relative density of forty samples was measured to determine whether different composition types could be detected using the method described above. The results showed no noticeable variation (Sewall 2011). The majority fall into a range of between 1.0 to 3.0 along a very gradual curve. Average relative density ranges from 1.5766 (G104) to 2.4151 (S400). There is minor variation from one excavation unit to another, with unit S400 having slightly denser conical rollers than the other units. However, there are no discernible groupings (*ibid*.).

Figure 4. A conical roller showing coarse clay with inclusions of small pottery fragments, shell and laterite. Photo: C. Sewall.

A range of sizes was clearly present within the sample based on field observation (Figure 5); there did not appear to be any standardized size types (see Sewall 2011). The tips show a range of diameters up to *c*. two centimeters within each group of measurements. At -5.0 centimeters down from the point, most are 1.6-2.0 centimeters in diameter. At -1.0 centimeters, most tips

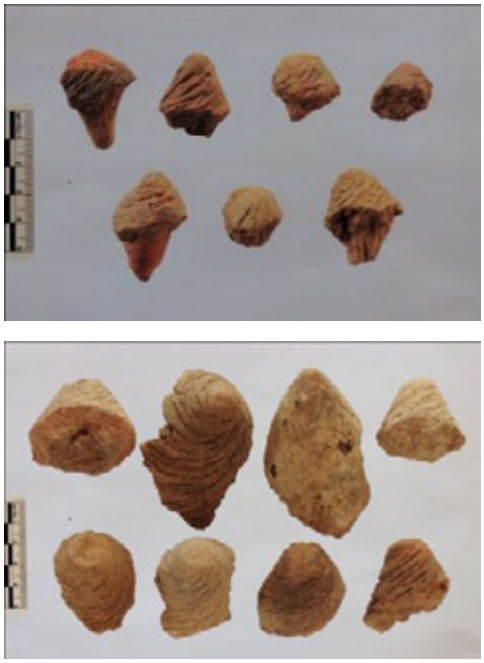


Figure 5. Examples of smaller (top) and larger (bottom) 'conical rollers'. Photos: C. Sewall.

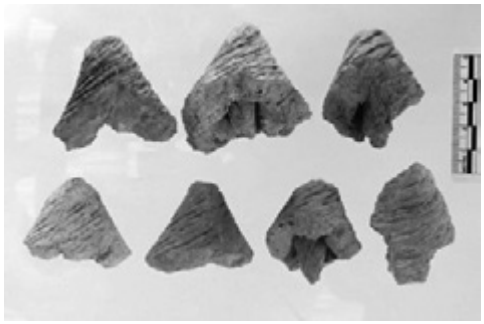


Figure 6. Type I conical rollers. Photo: C. Sewall.

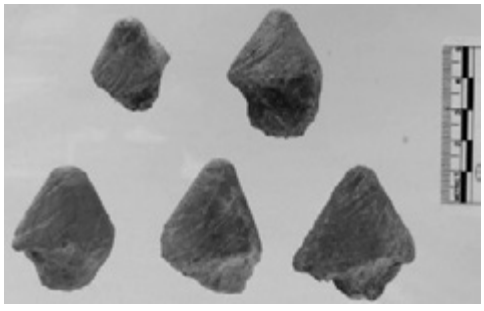


Figure 7. Type II conical rollers. Photo: C. Sewall.

fall in the 2.1-2.5 centimeters range. At -2.0 the diameter varied from 2.1-4.0 centimeters, but tips measuring 2.6-3.5 centimeters in diameter were most common. Only twenty tips were complete enough to measure at -3.0 centimeters from the top. Diameters ranged from 3.4-5.3 centimeters with no clear pattern or grouping within the measurements. For the length of the tip from the top to the bottom edge at the longest point, most of the conical rollers measured are 2.1-3.0 centimeters in length, although a significant number are in the 3.1-4.0 centimeter range, and just over half of those have sides of 4.1-5.0 centimeters in length. A total of forty-seven tails were measured, varying from 1.6-4.5 centimeters. As with tips, many of these are broken and there is little doubt that many shorter ones are incomplete (*ibid.*).

Shape was assessed by field observation and by measuring the angle at which the sides of the tip slope down and away from the point. The results show only a slight variation among all samples (Sewall 2011). While most conical rollers have a similar overall angle on the upper portion of the tip, the arrow-shape appears to be a distinctive form, with a clear separation between the tip and tail (Type I; Figure 6). These make up 19% of the sample. While the data show a far lower percentage of arrow-shaped tips compared to those that do not exhibit those characteristics (see below), it is not known how many of the broken or worn samples might have been arrow-shaped when complete. The other discernible type (Type II) does not have an arrow shape (Figure 7) and is characterized by its smooth red surface with thin, widely-spaced cordmarking. Only 4% of the sample showed these characteristics. Most conical rollers (77%) do not fall neatly into either category (*ibid.*).

Conical roller tips, with rare exception, were decorated by wrapping cord around the wet clay in a spiral pattern before firing. Diagonal slashes, apparently made with a sharp tool, are less commonly used (Sewall 2011). Many tips have closely-spaced markings, as do most fragments. 'Widely-spaced' is the next most common type of cordmarking for both tips and tails. A third distinct type is thin, widely-spaced cordmarking applied to a surface that is noticeably smoother compared to other types. Tails are often decorated with cordmarking or slashes, but it does not appear that cord was wrapped around in the same way as on the tip. Cross-hatched marks and slashes are often combined with cordmarking to make another type of decorative pattern found on a small number of tips and tails. Some cordmarked samples could not be categorized into any of the types above but displayed one or more of the attributes (Figure 8) (*ibid.*).

Many conical roller fragments appear to have broken off from the tip. Some have a curved shape to indicate this (Figure 9). Differences between the outer decorated surface and the inner roughly-formed side is another visible sign that the tip is where they were once attached. There are generally few signs of wear; the decoration is usually distinct. The degree of wear and breakage, measured on a scale of one to four (least to most extreme), is slight to moderate for most conical roller tips (Sewall 2011). The most common pattern of wear was the tip worn flat, either alone or in combination with moderate overall wear. A third of the tips showed slight wear on the tip. Together they point to a pattern of wear that was concentrated at the pointed end of the tip, rather than on the lower sides (Figure 10) (*ibid*.).

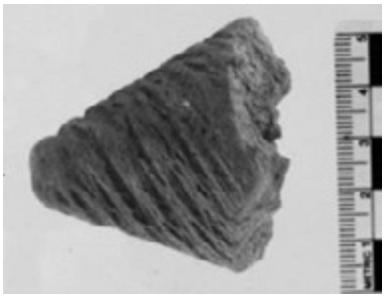


Figure 8. The most common cordmarking decoration. Photo: G. Stryker.

Chronological and spatial distribution

The Ban Non Wat conical rollers were found in predominantly Iron and Bronze Age contexts, with five found in a Neolithic context and three in a historic contexts. When soil volume is taken into account the number of artifacts from contexts interpreted to date to the Bronze Age is roughly double the number from interpreted Iron Age contexts (Sewall 2011). Unit S400 stands out as having a noticeably higher numbers in both periods; G104 has similarly high numbers only in the Iron Age (*ibid*.) (Figure 11).

Conical rollers were found in each excavation unit across the site (Figures 12 and 13). Units located nearest to the center of the mound had higher numbers compared with units located at the edge that contained only Iron Age material. In the five excavation units where conical rollers were found in the greatest numbers, they make up between 5-30% of the total number of artifacts (Sewall 2011). Artifacts most commonly found with conical rollers include a variety of tools used in bronze casting and pottery production, weaving and domestic life (e.g.

Figure 9. A curved fragment. Photo: C. Sewall.

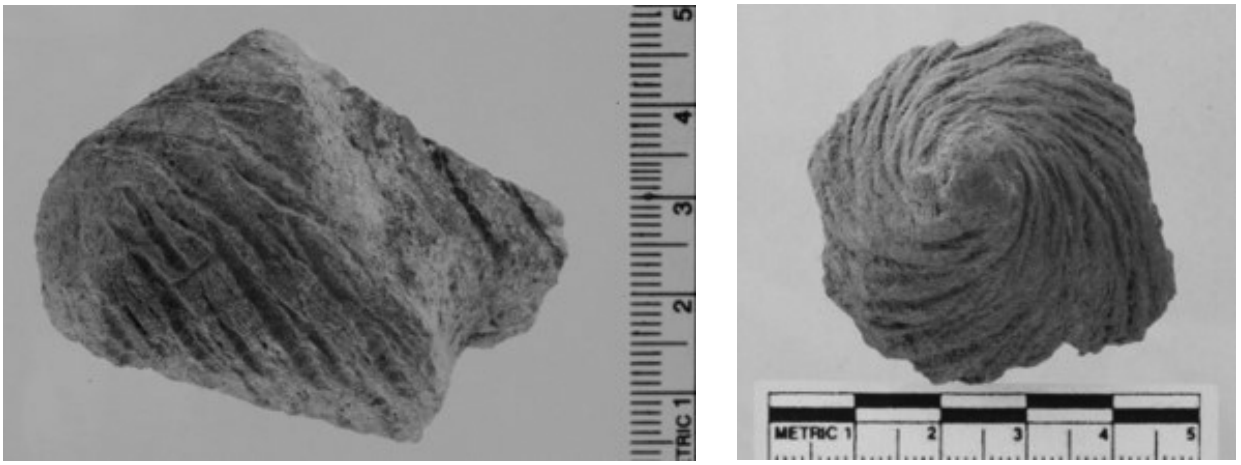


Figure 10. Degrees of wear: a) moderate, b) almost none. Photos: C. Sewall.

Higham 2002): spindle whorls, bronze and iron fragments, crucibles, slag, clay anvils and burnishing stones. Bronze and iron tools, ceramic vessels, bangle fragments, clay pellets, adzes, whetstones, counters, pieces of burnt clay and daub fragments were often found associated as well.

Most conical rollers were recovered after soil excavated from the general spit was sieved. Others were found in features such as pits, postholes, pottery concentrations, hard surfaces or floors (Sewall 2011). Several smithing hearths and furnaces could possibly have an association. In units S400, N96, N100 and O/P300 in particular, conical rollers were often found in red sandy or silty soil that contained crushed pottery and shell. Conical rollers were only occasionally found in grave fills, and they were not clearly in direct association with the body or with burial goods. However, in unit G104 one conical roller was found next to the feet of one burial (B650) and inside a whole pot at the head of another (B646) (*ibid.).*

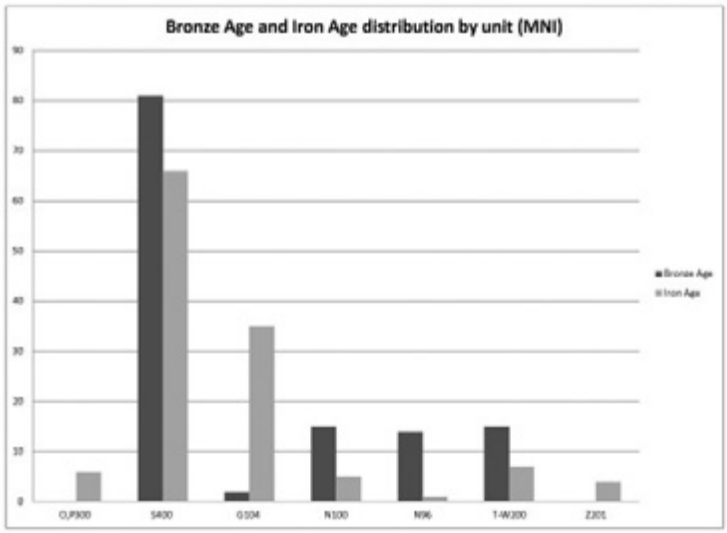


Figure 11. Chronological distribution of conical rollers across the site (after Sewall 2011).

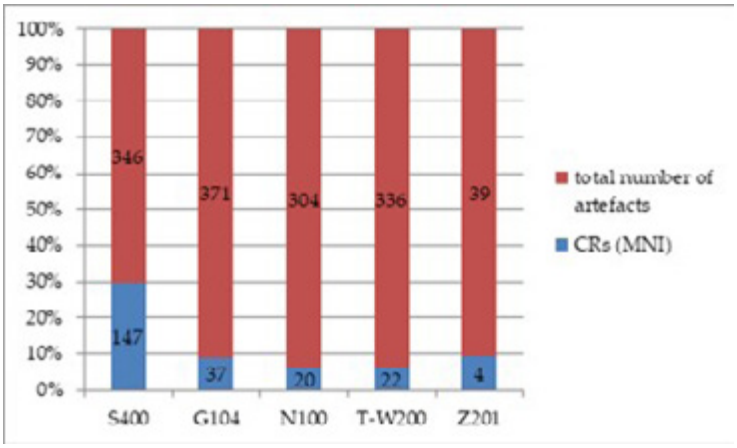


Figure 12. Conical rollers as a percentage of total artifacts by unit (after Sewall 2011).

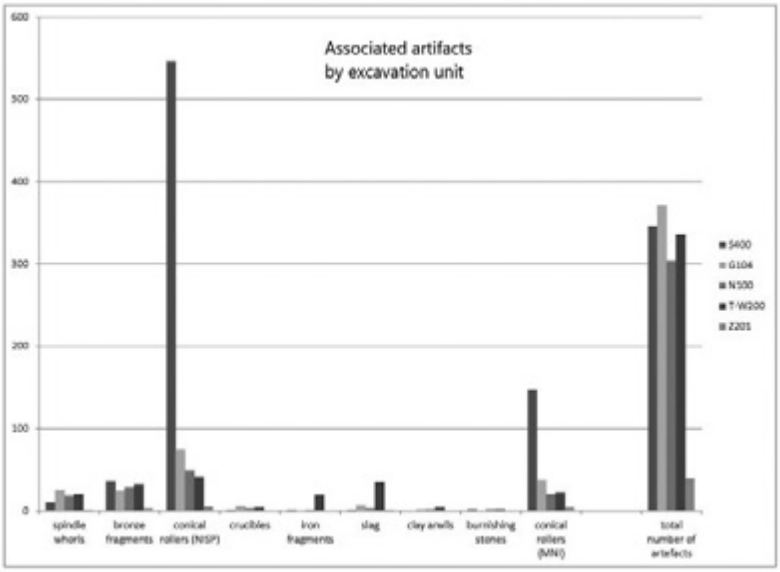


Figure 13. Conical rollers and commonly associated artifacts (after Sewall 2011).

Conical rollers display homogeneity in terms of virtually all variables considered. The distributions of size, density, form and surface decoration fail to reveal groups that might reflect change over time, style or use. There is no consistent relationship with pits, postholes, floors or mortuary deposits, nor is there with other types of artifacts.

Discussion

All conical rollers seem to be of a similar overall shape. This form must have been best suited to the function, as it remained unchanged throughout its existence. Types I and II are two recognizable variations. Because far more conical rollers and fragments have closely-spaced cordmarking, many of the ones that could not be assigned as either Type I or Type II most likely belong to the former. Type II conical rollers were found within a more limited area of the site; this could be significant, but without more information interpretation of this pattern is not possible. Conical roller size varies within the sample, but not by a significant amount. No chronological or spatial distribution pattern relative to size was found; perhaps variations are linked to the personal skills and preferences of the maker(s). Alternatively, it is possible that the function of conical rollers required these slight differences. The attributes of shape, size, patterns of wear and breakage, and decoration are in general all relatively consistent, supporting the idea that conical rollers appear to have been designed for one particular purpose (Sewall 2011).

Relative density varied to some extent from one excavation unit to another. Unit S400 had conical rollers with the highest average relative density. Overall, however, there do not seem to be any discernibly significant groupings, indicating that for the most part conical rollers were made with the same clays using the same manufacturing process as pottery (Sewall 2011).

The degree of wear and breakage is highly variable. The pattern of wear appears to be at the narrow end of the tip where in many cases it has been worn flat (Sewall 2011). Lower on the tip, surface wear is usually slight, and the grooves made by cordmarking are distinct. The condition of some of the larger fragments suggests that breakage occurred most often at the bottom edge of the tip. The wear on the

top suggests a function where the tip came in contact with another surface in a rubbing or grinding motion. While tails were often broken or completely missing, the amount of wear was generally minor (*ibid*.). This is consistent with the idea that they were held while the tip was used in some way.

The cordmarking characteristic of conical roller tips has two components: the width of the cord used to wrap around the tip, and the proximity of one wrap of the cord to the next. These characteristics vary, but despite slight differences the similarity of one to another makes it likely that all conical rollers were decorated to appear and to be used in the same basic way (Sewall 2011). If the decoration was designed to be functional, the usefulness would have come from the rough texture on the tip made by the cordmarking. Decoration on the tail was not consistent. Widely-spaced cordmarking and slashmarks were found on some conical roller tails, others had no markings at all (*ibid*.). Perhaps this indicates that the tail was held and was not the functional portion of the conical roller, as the decoration would have had to be more uniform in that case.

The red tint that is characteristic of most of the Type II conical rollers is the only observable pattern related to color without further study (Sewall 2011). Variations found within the sample are most often attributed to differences in firing atmosphere that occurred during the process of making them. However, it is possible that variations resulted from some other cause, such as extreme oxidation at the tip if they were used as plugs in bronze casting (W. Lucius, personal communication, 14 December 2010).

Analysis of distribution patterns for conical rollers has led to several interpretations of their possible function (Sewall 2011). Artifacts associated with bronze casting and weaving co-vary somewhat with those of conical rollers, in some excavation units more than in others. Bronze casting is indicated by the presence of bronze fragments, molds and crucibles. The chronological distribution pattern of bronze fragments has some similarity overall to that of conical rollers in units G104, N100 and T-W200. Spindle whorls are also distributed in a pattern similar to conical rollers. However, the general pattern for conical rollers is not similar enough to that of either artifact type for a conclusion to be drawn about their connection to either weaving or bronze making. There was no correlation between conical rollers and any artifact type related to pottery production. Unit S400 is generally similar in its distribution pattern to other excavation units, but the association with bronze fragments and spindle whorls is far less obvious. Distribution patterns from the first phase of excavations show a stronger correlation with these artifacts, but conical rollers do not significantly co-vary with either type (Sewall 2011). These patterns support the theory that conical rollers could have been associated with weaving or bronze casting during the Bronze and Iron Ages at Ban Non Wat, but the evidence is not substantial. However, in three of the four units with the highest number of conical rollers, there were also significant numbers of both spindle whorls and bronze fragments (*ibid*.).

Conical rollers are commonly found in association with many artifact types, from bangle fragments to clay pellets, from whetstones to clay anvils. It is impossible to say with any certainty that conical rollers are associated with one particular domestic or industrial activity. But there is substantial evidence for the association of conical rollers with some kind of industrial activity. They are often found in contexts with hard floors, clay furnaces, and concentrations of sandy soil with crushed shell and pottery. Unit S400 had an especially large amount of this soil type in the same context as the highest number of conical rollers found anywhere on the site (Sewall 2011).

In mortuary contexts, artifacts such as spindle whorls and grey clay, both associated with fabric production, are often found close to the body, and clay molds associated with bronze casting are regularly found. Clay anvils employed in pottery manufacture, and metal chisels and axes, perhaps used in woodworking, are also common. Conical rollers, however, are found in direct association with burials

far less often, and there appears to have been no regular practice of including them with grave goods. This suggests that they were not generally considered appropriate for placement in graves with other artifacts related to weaving, bronze casting and pottery production (Sewall 2011; Higham and Kijngam 2011, 2012a, 2012b).

In contemplating the function of conical rollers, it is helpful to hypothesize about the maker's intent by analyzing the particular attributes that were chosen when creating them. The purpose of the tail may have been to create a handle for controlling the motion of the tip. The tip was presumably cone- or arrow-shaped and cordmarked in a spiral pattern because it was appropriate for a particular task. It is also important to consider the possible motions that created wear and breakage patterns. In this case, the tip point became worn through use, sometimes to the point of being flat; the lower sides remained relatively unworn. Fragments from the edge of the tip commonly broke off, but the wear on the broken edges implies that they were still useful even after losing these pieces. It is possible that it was used to grind something moderately soft, using it by holding the tail as a handle. Another possible function is as a weight held 'upside down' by the tail, while the tip was swinging against a surface.

Bronze casting, weaving, pottery and salt making, as well as activities related to domestic habitation, have been well documented at Ban Non Wat, and it is possible that conical rollers had a function related to one or more of these industries. One possibility is that conical rollers were used as plugs for molds during the lost wax method of bronze casting (as noted above; W. Lucius, personal communication, 14 December 2010). The Luristan bronzes from Iron Age Iran were made by this process, for example, and it is thought that clay plugs were used to seal up the holes in the mold before pouring in the bronze (Wilbur 1991). Based on evidence from other sites in northeastern Thailand (Higham 2002: 166), this method of casting was very likely used at Ban Non Wat. Also, a number of bronze bells that would have been cast by this method were found during the first phase of excavation (C. Higham, personal communication, 16 December 2010). Conical rollers have a suitable shape for this function. Used as a plug, a conical roller tip would have filled a relatively small circular or funnel-shaped space. The tail would have been used as a handle to insert the plug. There is no way of knowing if the holes in the mold would have matched the shape and size of conical rollers, as molds were broken during the process of removing the bronze object. Cordmarking may have made conical rollers suitable as plugs. The rough surface and spiral pattern may have allowed them to be secured by a screwing motion. Inserted this way, the lower tip of the conical roller may have protruded and broken off at the edge, creating the observed pattern of numerous lower tip fragments.

While it is possible that conical rollers functioned as mold plugs in the lost wax method of bronze casting, there is only limited support for this theory. The fact that clay plugs were used for bronze casting during the Iron Age in Iran does not mean they were used in Thailand. While the chronological and spatial distribution patterns of conical rollers do co-vary to an extent with bronze fragments, there is no strong association. The wear pattern is not consistent with this function either. A plug is not expected to move in a way that would make it worn at the tip, as most conical rollers are. Finally, it would be expected that some remains of molten bronze would adhere to the surface of at least some conical rollers, yet this is not the case. Analyzing the tips for bronze residue would be useful for further testing of this hypothesis.

Conical rollers may have functioned as plugs for something besides molds for bronze casting. There are no ceramic vessel types known from the site with an opening of a size that matches any of the conical rollers. However, it is possible that a container made of an organic material such as bamboo or leather would have an opening of a similar size. As previously discussed, the pattern of spiral cordmarking would be helpful in securing the plug, and the tail would function as a handle. Breakage along the edges

would be expected. The wear pattern on the tip, however, still makes the idea that conical rollers were used as plugs of any kind unlikely (Sewall 2011).

Several possible functions related to weaving have been suggested for conical rollers. They could have been used to create a pattern on fabric, a theory suggested for the cylindrical clay rollers from Ban Chiang and Lao Pako (Karlström 2000: 90). It is more likely that cylindrical rollers were used for this purpose, because the shape would leave a straight row of pattern; a conical shape would not roll in a straight line, and therefore conical rollers seem ill-suited for applying pattern to fabric (Sewall 2011). They could have functioned as bobbins or spools for holding thread. The cordmarking would have been useful for keeping the thread from sliding off. The handle would have been held or placed in something during the process of winding and unwinding. Bobbins of a similar shape were included in a typology of pre-Roman pottery spools, but not all scholars agree this was their function (C. Higham, personal communication, 1 January 2011; Sewall 2011: fig. 5.9; see e.g. Gleba 2009; Phelps 2012). If they were bobbins or spools, it makes sense that they were found in association with so many spindle whorls, used for making thread.

Another artifact type associated with weaving is the loom weight. These are often circular or triangular with a hole for attaching the thread, which would provide tension during the weaving process. Conical rollers are unlikely to have been loom weights: they are not found in groups, as loom weights often are, and they have no hole bored through them. It is possible, though, that the thread could have been secured by using the cordmarks to catch the thread within the grooves and making a knot around the tail. The conical roller would then hang with the tip down, perhaps wearing down the point as it came in contact with the ground (Sewall 2011). It is tempting to conclude that, because they occurred at the same time and have a similar distribution pattern to spindle whorls, conical rollers were associated with weaving. However, there are not enough data to fully support this theory. If their function was related to fabric production, it is possible that they functioned as bobbins or spools for collecting and storing thread or yarn. It is unlikely that they were used as either loom weights or as rollers for applying decoration.

It has been suggested, both with regard to the conical rollers from Ban Non Wat and the pre-Roman pottery spools mentioned above, that they may have functioned as spacers in kilns to support the weight of the pottery and to provide stability (e.g. Hackworth 1993 cited in Gleba 2009). Several attributes, such as the carefully-applied cordmarking and the overall shape of the conical rollers, makes them appear ill-suited to this function. The pattern of wear on the pointed part of the tip, the tip surface roughened by cordmarking, and the tail which may have been used as a handle all suggest a function related to grinding or grating. It is important to note that the wear is usually confined to the point and not along the sides of the tip, indicating a very specific range of motion (Sewall 2011). If conical rollers were used as spacers, a greater area of wear might be expected.

These same characteristics, as well as the symmetrical arrow shape of the tip, are similar to those of many spinning tops that are found in many cultures, past and present. It may be that a thread was wound around the tail and pulled, setting it spinning, or perhaps the tail was held in the fingertips and spun. Its size is suited for either possibility. The distribution patterns make little sense in this case, however, with their relationships to industrial contexts in such great numbers.

It appears unlikely that conical rollers functioned as a symbolic representation of male fertility, as some have suggested (e.g. Higham and Kijngam 2009: 248). They are only very occasionally found in mortuary contexts, and when they are, there is no strong association with any particular area of the skeleton as there is with bivalve shells which are interpreted as being symbols of female fertility (*ibid.*). If these artifacts were ritual objects, it seems likely that they would have been found more regularly in burials rather than scattered among the features and within the general excavation material.

Conclusion

Conical rollers are found at Ban Non Wat and nowhere else. They became common during the Bronze Age and early Iron Age, after which their numbers decreased. This pattern co-varies to some degree with those of spindle whorls and bronze fragments, suggesting the possibility that conical rollers were used in weaving or bronze casting. However, they were not regularly included in burials, as were other artifacts related to these industries. Several possible functions are suggested by the shape, size, decoration, and use-wear patterns of conical rollers. Whatever their function(s), the frequent appearance of conical rollers across the site indicates that it was a common activity.

Other questions about this artifact type remain unanswered. The assemblage of artifacts from Bronze and Iron Age contexts at Ban Non Wat is quite similar to those found at other sites across Southeast Asia, with the exception of conical rollers. Was there an activity taking place at this site that was not occurring elsewhere? Was the clay conical roller an object that, in other places, was made of wood or bamboo, so that only the ceramic version of the artifact remains? Why are conical rollers largely absent from burials, while most other artifact types are included among the range of grave goods? The question of what these artifacts should be named is another unresolved problem. The term 'conical roller' implies a particular function and a similarity to the artifacts called rollers found in Thailand, India, Iraq, Egypt, and the Mediterranean coast (Porada 1993: 563; Skeates 2007: 185). There is no function implied by the term 'conical', but it does not reflect the presence of the tail or handle portion of the artifact. If this study had identified the function of conical rollers, a suitable name to replace the current one would have suggested itself. However, since the name has already entered the literature, it will remain until a more suitable one can be found to replace it.

There is clearly more research that needs to be done in order to understand the place of these unique artifacts in the material culture Ban Non Wat and Southeast Asia. Future studies should include fabric analysis, use-wear analysis, testing for residues, and closer examination of the composition of conical rollers. This study forms a baseline for further research which, it is hoped, will one day reveal the role of conical rollers. For the present they remain enigmatic and unique.

Late Pleistocene/Holocene ecological and cultural transition in the Philippines

Jonathan H. Kress

Introduction

The archaeological site of Ille is a large cave penetrating a limestone tower in the eastern Dewil Valley outside Barangay New Ibahay of El Nido Municipality in Northern Palawan (Figure 1). Excavations have been conducted there with few interruptions since the late 1990s under the direction of the Archaeological Studies Program of the University of the Philippines and the Philippine National Museum, revealing cultural remains dating from the nineteenth century AD to the late Pleistocene, concentrated within and directly outside two large openings (east and west mouths) in the southern face of the tower (Paz 2002; Szabó *et al.* 2004; Pawlik 2004; Solheim *et al.* 2006; Lewis *et al.* 2008). During the 2007 season two significant pieces of data emerged from the ground in the west mouth. One was the molluscan faunal documentation of the marine transgression at the end of the Pleistocene; the other was the presence of an innovative, intricate and highly idiosyncratic lithic technology which flourished briefly in the terminal Pleistocene and disappeared completely thereafter.

Late Pleistocene molluscan fauna: the ecological context

As part of the 2007 season, excavations were conducted in two squares (W14-15 N5) directly below the opening of the west mouth of the cave. The excavators of these squares were the author and Jane Carlos, at the time a graduate student in the Archaeological Studies Program at the University of the Philippines. In order to better understand the nature of the sediments we were excavating, we began a count of mollusk remains as they were removed from the earth. The shells were identified by ecological classification based on the author's experience. The classificatory units were twelve-centimeter lifts (samples taken in spits; Figure 2) beginning at 125 centimeters below the designated lower datum point for the trench: Lift I: -125 to -137, Lift II: -137 to -149, Lift III: -149 to -161, Lift IV: -161 to -173, and Lift V: -173 to -185 centimeters. The mollusks were sorted into four major ecological categories:

- marine: saltwater mollusks including littoral and tide pool species
- estuarine: mollusks adapted to brackish water and tolerant of fluctuations in salinity; euryhaline species

Figure 1. Map of the Philippines showing site locations: a) Ille Cave; b) Pilanduk and Lipuun Point (Tabon Caves). Based on a map from the Bishop Museum, edited by J. Kress.

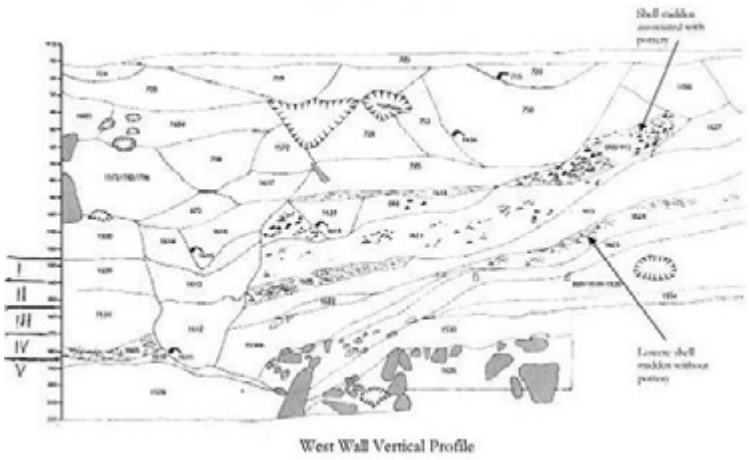


Figure 2. The depth of the spits ('lifts') sampled for mollusks for this research shown on the lower left of the west wall profile of the West Mouth trench at Ille Cave in 2007. Original field drawing reproduced from Archaeological Studies Program (2007), amended by J. Kress, and used with permission. This drawing from a 2007 report has seen many subsequent alterations and corrections (e.g. context 1534 was subsequently amended to 1578 etc.) and is used here merely to illustrate the locations of the 'lifts' and the state of play at the time.

- freshwater: mollusks living in still water ponds (lentic species) and in riverine environments (flowing water or lotic species)
- terrestrial: mollusks adapted to life on land.

In Lifts I and II the ecological distribution of the mollusks was typical of the later Neolithic period (*c*. 5500-3500 bp) that had been documented earlier in other parts of the excavations (Faylona 2003). All four major ecological zones were represented, but terrestrial species were rare – absent in the first lift and limited to two examples in the second. Marine species were well represented and diverse, reflecting opportunistic foraging habits. The estuarine mollusks were dominated by *Nerita* species and *Batissa*, a euryhaline species collected in the landward areas of the nearby mangroves. Moreover, the size of the shells varied greatly and was generally smaller than that of collections from earlier phases, possibly indicative of year-round collection and more frequent visitation of the site in the Dewil Valley. Twenty-nine species were recognized in the first lift, several of which were absent in the second, where four, possibly five additional species were recovered. Overall, however, the nature of the two assemblages was similar with only a slight diminution of marine species in the lower of the two.

In the third lift only ten species were identified, one of which was present in a single fragment of a large operculum. The incipient decrease in reliance on marine mollusks noted in Lift II increased dramatically in Lift III. Marine species were represented by a single *Strombus* shell, while the estuarine contribution to the diet was reduced to a single species – *Telescopium* sp. – represented by four shells. All other mollusks were of either freshwater or terrestrial varieties. By the fourth lift the elimination of marine and estuarine species was virtually complete – one lone purple *Batissa*. Two *Melanoides* shells represented the freshwater group. The assemblage was dominated completely by the shells of more than 500 land snails – overwhelmingly *Helicostyla satyrus* with a few *Obba* sp. examples. The fifth lift was dominated by the butchered carcass of a deer, represented by a series of roughly articulated neck and back vertebrae. The few shells that were collected mirrored the ecological distribution of Lift IV but were insignificant in number.

Two features of the molluscan sequence are significant, one of them puzzling. Missing from the sequence are the immediate post-Pleistocene and mid-Holocene deposits. The first are characterized by small concentrations of shells, largely and sometimes exclusively *Batissa*, some of which show clear signs of roasting (noted by the author). The latter consist of massive concentrations of *Batissa* (e.g. Lewis *et al.* 2008 'shell midden'), similar to those created by the Anbara of Arnhem Land described by Meehan (1977). This lacuna is possibly a factor of the proximity of excavated squares to the overhang of the entrance.

The other is the trend (with depth) toward total reliance on freshwater and terrestrial mollusks to the eventual total exclusion of marine and estuarine species – in temporal terms in the opposite direction. In this transition the late Pleistocene marine transgression appears to be reflected. The assemblages in the lower lifts were accumulated when the interpreted distance to the ocean (Robles *et al.* 2014), coupled with a possibly very different hydrology of the local river, precluded the facile exploitation of both marine and estuarine environments during visits to the cave. Such temporally differing ecological systems have also been demonstrated in the molluscan assemblages at Pilanduk Cave and Sa'gung Rockshelter in southern Palawan, the former a late Pleistocene site (26,000 to 20,000 BP), and the latter an early to recent Holocene site (Kress 2000). The following demonstrates this interpretation of the molluscan assemblages:

Lift	**Depth below datum**	**Sea level estimate**	**Proposed phasing**
#1	-125 to -137	present level	Holocene
#2	-137 to -149	at/near present level	Holocene
#3	-149 to -161	rising	transitional
#4	-161 to -173	lower	Pleistocene
#5	-173 t0 -185	lower	Pleistocene

This sequence cannot record the precise timing but appears to reflect a period of marine transgression which wrought extreme changes in the environment of the Dewil Valley and the environs of Ille Cave.

The presence of deer in the fifth lift supports the placement of these sediments in the Late Pleistocene, as there is little doubt in my mind that the island-wide extinction of deer occurred shortly after the slaughter of this particular animal. The proposed survival of deer well into the post-Pleistocene in Palawan rests largely on one C14 date on a single shell from the bottom of the cultural deposits in Guri Cave (Fox 1970: 45-47). This date was taken at face value before the problems with dating shell were understood and is likely unreliable. It has been responsible for not only erroneous conclusions about the extinction date of the Palawan deer, but also the misplacement of the Guri assemblage in the prehistoric chronology of the island and misconceptions of local cultural development. Fox himself was somewhat dubious concerning the late survival of deer in Palawan and the recent date for the Guri cultural deposits (Robert Fox, 1968, personal communication). Deer bones have been excavated at Ille in Late Pleistocene deposits. It has, however, been suggested that deer survived in certain areas, including at the Ille site, until the Neolithic (Ochoa 2009; Piper *et al.* 2009a), and I may soon have to revise my opinion.

Associated implements

Directly associated with or in close proximity to the remains of the deer carcass were six lithic implements which are important in that they represent the culmination of the Palawan Pleistocene lithic tradition, and demonstrate the persistence of very ancient lithic technology, and the durability of much earlier local knapping techniques combined with a highly innovative and imaginative technology.

The chopper

Shortly before the deer vertebrae were encountered a chopper was uncovered. It was manufactured on a uniformly fine, dark gray siliceous material with a brown patination and widely dispersed flecks of an orange mineral. The shape of the blank was well adapted to use as a tool – one flat surface (dorsal) opposed by one (ventral) sharply sloping from a relatively thick edge towards a fairly thin one (Table 1). Two fairly large flakes and several smaller ones were removed from the ventral surface of the thinner edge of the cobble. The removal of the two larger flakes created a point. Either of the two concavities or the point, or both, could have been the useful part of this tool. The point itself did, in fact, appear to have been broken during use – one small chipping scar dulls its end. Small chipping scars are also evident on the edges of the two large concavities and one of the smaller negatives.

The great scraper

A second core tool manufactured on a very dark andesitic material was excavated in direct association with the deer vertebrae. As with the chopper, it was an expedient tool to the extent that its knapper took advantage of the natural shape of the cobble to produce the implement (Table 2; Figure 3). The blank had two relatively flat surfaces which met each other at an approximate right angle. What became the ventral surface of the tool had been very smooth, while the vertical surface was naturally less so. The other three surfaces also rose roughly vertically from the ventral surface, while the dorsal surface had a somewhat convex shape which fit nicely into the hand. Where the two flat surfaces met, a recessed edge had been created by the use of hinge fracture, a prominent feature of the upper Pilanduk assemblages of 23,000 to 20,000 BP (Kress 2006). One can only speculate about the use of such an implement. It may have been useful in cleaning hides – sharp enough to clean the interior or exterior of the skin, yet dull enough to do no damage. Yet in experiments conducted with such a tool in 1970, I found that the recessed edge clogged with fat so quickly as to render the tool useless for such purposes without frequent cleaning. Pilanduk Cave, where such tools (much smaller) were found, was quite far above the nearest source of water. Perhaps they were made for dealing with bone or wood. A previous study of lithics from Ille Cave suggested most finds were expedient and probably used for processing plant materials (Lewis *et al*. 2008).

The blades

Two tools were recovered in close association with the deer vertebrae which possess attributes indicative of a nascent blade technology (Table 3; Figures 4 and 5). These were manufactured on the same andesitic material as the core tools. They were virtually identical in form and metrical dimensions. They both preserved very small striking platforms, and were clearly detached from a carefully prepared core, probably even the same core. The two lateral edges are roughly parallel (at least they were apparently intended to be) and were, with the distal edge, or largely equal utility. What is clear is that the final shape and appearance of the tools was of importance to the knapper(s). Most importantly, they contrast strongly with the elongated flakes of the earlier Tabon-Pilanduk tradition, where

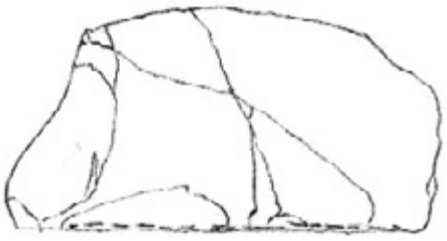


Figure 3. Large scraper IV-1998-P-37103, showing recessed working edge. Drawing by J. Kress; for dimensions see Table 2.

Table 1. Chopper IV-1998-P-37104

Greatest length:	8.9 cm
Greatest width:	12.2 cm
Greatest thickness:	5.5 cm
Weight:	*c.* 580 g

Table 2. Scraper IV-1998-P-37103

Greatest length:	11.5 cm
Greatest width:	5.8 cm
Greatest thickness:	5.8 cm
Weight:	425 g

there is little or no control of shape or form seen. The production of one or more sharp edges was sufficient to meet the needs of the knappers in and of itself, and little attention was paid to the final shape and appearance of the implements (author's observations).

Table 3. Tools: IV-1998-P-37101 and IV-1998-P-37106

Tool: IV-1998-P-37101	
Greatest length:	7.2 cm
Greatest width:	4.2 cm
Greatest thickness:	3.5 cm
Weight:	*c.* 100 g
Material:	andesitic with biotite
Stage of manufacture:	flake
Dimensions of striking platform:	
greatest width:	2.1 cm
greatest thickness:	0.6 cm
Tool: IV-1998-P-37106	
Greatest length:	7.0 cm
Greatest width:	4.0 cm
Greatest thickness:	2.4 cm
Weight:	*c.* 50 g
Dimensions of striking platform:	
greatest width:	3.9 cm
greatest thickness:	2.0 cm

The core tools

The final two artifacts were core tools manufactured on blanks of a material similar to that of the other tools, but with an unusual shape (Figures 6 and 7; Table 4). On both tools, parts of three to five of the original faces are preserved, with the preserved opposing fragments parallel to each other. In both cases the working edge or major working edge is perpendicular to what had been the long axis of the blank. To achieve this result, the blank had to be thinned from the dorsal surface in such a way as to leave a longer, very thin, protruding ventral surface. What is most interesting is the manner in which this was done.

Thinning was presumably begun by striking flakes with feathered terminals parallel to the long axis of the tool. Traces of this knapping remain above the working edges of both tools. Flakes of this kind were also probably struck from the dorsal surface of the blank. Further trimming was accomplished with the intentional use of step fracture terminals, also struck from the dorsal surface. This type of terminal rarely appears on finished tools in lithic technologies except in the production of burins. In most other cases its appearance is unintentional. When an edge sufficiently thin was achieved, it was retouched from the ventral surface probably using a soft hammer to create bending fractures (in which the critical – fracture – point is deflected away from the point of impact) producing a curving serrated edge.

Figure 4. Tool IV-1998-P-37106. Drawing by J. Kress.

Figure 5. Tool IV-1998-P-37101. Drawing by J. Kress.

On one lateral edge of tool IV-1998-P-37102 (Figure 6) an additional working edge was created with hinge fracture, the intentional use of which, as noted above, is both rare and locally distinctive; it is found in Pilanduk assemblages I to III, in which this was frequently used to create undercut edges on relatively thick flakes . The implement is unusual both in that it is a composite tool with two very different working edges, and in that its final useful form involved a rare combination of knapping techniques which produced feathered, step, hinge, and bending fractures (see Andrefsky 1998: 85-87 and Whittaker 1994: 106-112, 189 for a description of these techniques).

Figure 6. Core tool IV-1998-P-37102. Drawing by J. Kress.

Figure 7. Core tool IV-P-1998-37000; for dimensions see Table 4. Drawings by J. Kress.

These six implements demonstrate both continuity and innovation in the Palawan lithic tradition. The use of hinge fracture to create working edges on two of the implements echoes the much earlier assemblages of Pilanduk, while the two flake tools can be interpreted as a refinement of much earlier technologies seen at both Tabon and Pilanduk. The final two core tools are unique and testify to the skill and ingenuity of the knappers.

Finally, the andesitic rock is not known to be available in the immediate vicinity of Ille, except perhaps as stream cobbles, and there is no debitage of this material which would indicate local manufacture (see also Lewis *et al.* 2008), suggesting that the foraging patterns of the people who periodically visited Ille during the late Pleistocene took them over a wide geographic range and probably brought them into contact with numerous similar groups with equally large home ranges and access to locally 'exotic' materials.

Discussion

It is important to note that this molluscan depositional sequence has not been documented in the east mouth of Ille to date (E. Robles and J. Carlos, 2012 and H. Lewis 2019 personal communication). However, there is clear change in sedimentary depositional history which appears to relate to change in the stream system in and/or around the karst, and marine mollusk remains are mainly found in the later 'Neolithic' and later layers (Lewis *et al.* 2008). Despite collection of mollusks for over ten years, we have yet to find a researcher willing to undertake the substantial project of quantifying the environmental, landscape and subsistence record of the shells at Ille and nearby sites (Helen Lewis, 2019, pers. comm). There have been studies of use of shell as a material for tools and ornaments (e.g. Szabó 2004; Basilia 2012; Vitales 2013), but only one article has been published on the shell assemblage as an environmental proxy and dietary indicator (Faylona 2003). This work is greatly needed, and, while the shell remains are

Table 4 Core tools IV-1998-P-37102, IV-1998-P-37000

Core tool IV-1998-P-37102	
Greatest length:	7.2 cm
Greatest width:	4.2 cm
Greatest thickness:	3.55 cm
Weight:	*c.* 100 g
Material:	andesitic, flecks of biotite, quartz
Stage of manufacture:	core tool; retouched cutting edge
Core tool IV-P-1998-37000	
Greatest length:	8.25 cm
Greatest width:	5.9 cm
Weight:	c. 150 g
Material:	andesitic, flecks of biotite, orange patination
Stage of manufacture:	core tool; composite: sharp cutting edge, recessed hinge fracture edge

just a part of this paper, I urge more researchers to undertake this important work with this substantial collection.

The crude drawings of the artifacts were completed quickly at the end of 2007 excavation season. The one excuse I can offer for their quality (or the lack thereof) is that the objects have been unavailable since May 2007. I can only hope that they to some degree reflect the complexity that the extensive working and reworking of the original blanks produced. The unique combination and diversity of knapping techniques represents unusual skill and creativity. At present these few tools represent the final products of the long southern Philippine knapping tradition evidently brought to an end by environmental, adaptive and social changes enforced on the local population by the dramatic marine transgression of the terminal Pleistocene.

The nature and the timing of this marine transgression and its effect on human populations are two of the most interesting and important questions facing archaeologists and prehistorians. Here, near the eastern end of the Sunda shelf, we have a dim view of both issues, a view which raise as many questions as it answers. This particular cave profile has not been dated thus far. The recorded transgression does not address the question of the separation of Palawan and its neighboring islands to the north and south from Borneo and the rest of the Sunda shelf. It records only a proxy record of the encroachment of the ocean on the Dewil Valley, and the human reaction to the significant changes in the local environment created by that encroachment. The changes in foraging habits and the lithic technology are clearly evident in the regional data. At Ille, the exploitation of terrestrial mollusks virtually ended and that of freshwater species diminished significantly, while the use of hinge fracture as a knapping technique disappeared. Deer also disappeared fairly quickly from the locally-exploited fauna, as the exploitation of marine and estuarine environments increased rapidly. What is the connection between these phenomena? Is there any? Can the butchering of pig and other mammalian fauna be so different from that of deer as to render a knapping technique that had endured for at least 9,000 years totally obsolescent? At present we can only speculate; hopefully, further additions to our knowledge of this period will cast a brighter light on these issues.

It is also important to note that the source rocks from which these tools were manufactured appear to be foreign to the Dewil Valley, although some may occur as stream cobbles (Lewis *et al.* 2008). Ille Cave is a unique and dramatic site and was clearly a socially important spot for all the inhabitants of the valley and perhaps individual bands, clans, extended families from a much greater area. People inhabiting the immediate area were, no doubt, part of an extensive nexus of interacting social units whose societal, ceremonial, and subsistence needs brought them annually or more frequently to this remarkable place where the exchange of goods and gossip was accomplished, and ties were renewed and reinforced. After all, do we ourselves not do the same there every April?

Acknowledgments

The fieldwork producing this material was conducted by the author and colleagues in the Palawan Island Palaeohistory Research Project, directed by Victor Paz (University of the Philippines Diliman), Helen Lewis (University College Dublin) and Wilfredo Ronquillo (then at the National Museum of the Philippines), and the 2007 season was funded by the Coral Bay and Rio Tuba Nickel Mines, the British Academy, the Solheim Foundation, and the Archaeological Studies Program at the University of the Philippines Diliman.

Middle Pleistocene sites in Bukit Bunuh, Lenggong, Perak, Malaysia

Nor Khairunnisa Talib, Mokhtar Saidin and Jeffrey Abdullah†

Bukit Bunuh is situated in Lenggong Perak, which is part of a meteorite crater formed around 1.83 million years ago. Based on excavation and survey in 2008-2010 at the west of Bukit Bunuh, a stone tool workshop was revealed which has marked a new era for Paleolithic study in Malaysia. Optically Stimulated Luminescence dating suggests this site was used around 270,000 and 490,000-550,000 years ago, with over one hundred thousand lithic artifacts found. The site appears to be in situ based on artifact associations, conjoining artifacts, and undisturbed stratigraphy. The raw material of the artifacts found is different from other open sites in Lenggong, as the impact of the meteorite resulted in the formation of a variety of raw materials, such as suevite, cherty metasediment, quartz and quartzite, which appear to have been quarried. Artifact association shows stone tool production through direct and indirect percussion, and edge trimming. Geomorphological and soil studies suggest the Paleolithic people of Bukit Bunuh had adapted to a lake environment.

Introduction

Lenggong Valley, Perak, Malaysia, is no stranger to archaeologists seeking to crack the puzzles posed by prehistoric artifacts (e.g. Zuraina Majid 2003: 3). Archaeological studies began in the area in 1938 and gained momentum since 1988. Researchers who have conducted studies on Paleolithic open sites in the valley include Collings (1938), Sieveking (1958), Zuraina Majid and Tjia (1988) and Zuraina Majid (1989a and b). All these previous studies were carried out at the Kota Tampan site. However, the work done by Zuraina Majid (1997) became the starting point for more detailed scientific studies. Several other sites have been identified in Lenggong Valley, including Kampung Temelong (Mokhtar Saidin 1997a), Lawin (Mokhtar Saidin 1997b), Bukit Bunuh (Mokhtar Saidin 2006a) and Kota Tampan 2005 (Hamid Isa 2007).

Previous studies have revealed that the Lenggong Valley was inhabited by early humans very early, based on chronometric dating of a hand axe found buried in a suevite boulder at Bukit Bunuh (Mokhtar Saidin 2010: 81). Based on excavation and survey in 2008 to 2010 at the west of Bukit Bunuh, a stone tool workshop dating to the Middle Pleistocene was found. Optically Stimulated Luminescence (OSL) dating suggests this site was used around 270,000 and 490,000-550,000 years ago. This makes it the oldest intact evidence of an *in situ* stone tool knapping workshop in Lenggong Valley.

The open site is located at 100°0 58.5’ East and 5°0 04.05’ North, at an altitude of 98-103 meters above sea level (Figure 1), and approximately ten kilometers south of Lenggong town, lying between two mountain ranges called Banjaran Titiwangsa and Banjaran Bintang (Figure 2). The main river irrigating this valley is Sungai Perak, which flows through the western part of the area.

Previous research in Bukit Bunuh

Bukit Bunuh was discovered around the year 2000 during a mapping exercise to locate archaeological sites (Mokhtar Saidin 2006a). The area showed indications that it may contain interesting geological and archaeological evidence. Based on a geological survey, Mokhtar Saidin (*ibid*.; 2010) had determined Bukit Bunuh to be part of a crater formed by a meteorite impact 1.83 million years ago. The morphology of this crater was proposed via interpretation of satellite images and aerial photographs (Nor Khairunnisa

Talib *et al.* 2009: 176; Tjia 2001: 70). The impact of the meteor strike bequeathed Bukit Bunuh with a diversity of rock types, including quartz, quartzite, and meteorite impact metasediments (chert, flint, agate and suevite) (e.g. Vernon and Clarke 2008). The presence of suevite is an important indicator of an impact event (Stöffler and Grieve 2007: 7). This stone is a rock which typically forms a breccia, which contains angular clasts set in a fine-grained matrix created by shock metamorphism. Rapid metamorphism also produced the alternating lamellar quartz minerals found in the crater. It was found that the original rock formations in Bukit Bunuh had undergone great changes in temperature and pressure due to the meteorite impact (Mokhtar Saidin 2006a; Nor Khairunnisa Talib *et al.* 2009: 176). Further studies on the impact formations include Jinmin *et al.* (2013a, 2013b), Samsudin *et al.* (2012, 2014) and Nur Amalina *et al.* (2018).

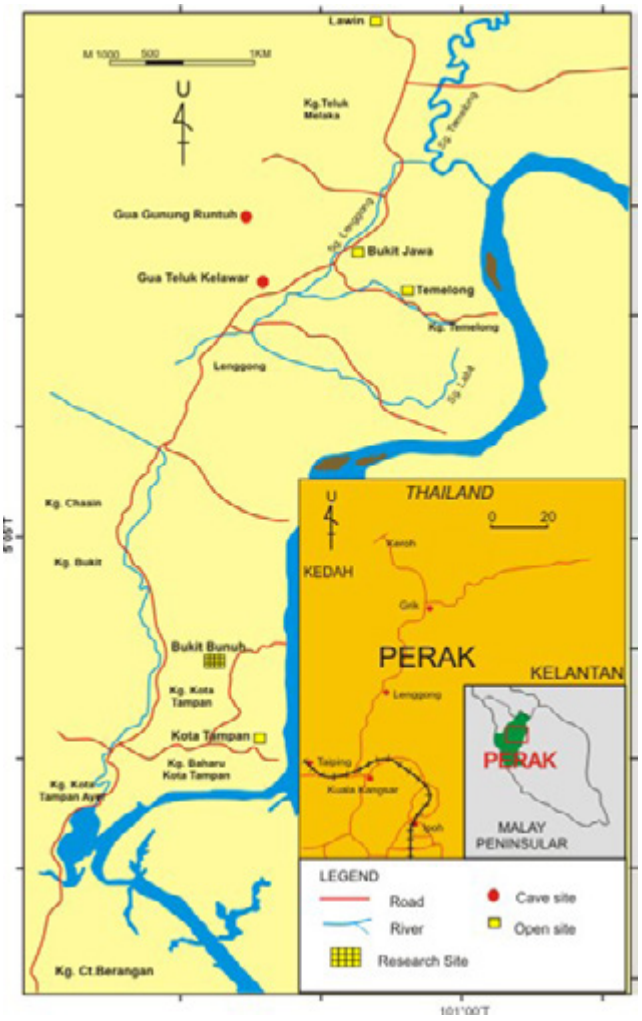


Figure 1. Map of the archaeological sites in Lenggong Valley. After Nor Khairunnisa Talib (2013, based on Mokhtar Saidin 1997a and b).

Based on archaeological studies, Bukit Bunuh evidently contains at least one *in situ* site which served as a lithics workshop during the Paleolithic, but it is part of a huge Paleolithic complex encompassing several sites within a three kilometer radius. These sites appear to have had similar functions, based on the discovery of various raw materials for toolmaking dated to different periods (Mokhtar Saidin 2006a). Excavations in 2001-2003 uncovered significant archaeological evidence which better illuminates the cultural sequence for the Lenggong Valley. In the southern part of Bukit Bunuh, excavation trenches were positioned based on indications of thicker and potentially undisturbed cultural layers. Artifacts recovered from this site include stone anvils, hammerstones, core tools, flaked tools, pebble tools and debitage (*ibid.*).

Mokhtar Saidin (2006a: 62) classified the artifacts of Bukit Bunuh into three categories: tools, stone tools and debitage. The assemblage was similar to those recovered from other open-air Paleolithic site excavations in the valley, including Kota Tampan 1987 (Zuraina Majid 1989b), Kota Tampan 2005 (Hamid Isa 2007: 150), Temelong (Mokhtar Saidin 1997a: 69), Lawin (Mokhtar Saidin 1997b: 100), and Bukit Jawa (Zuraina Majid 1997: 49). Based on the knapping techniques employed, the assemblage is also similar to those sites, involving direct and indirect percussion, and edge shaping. However, it was in Bukit Bunuh that a hand axe was found for the first time (Figure 3). This discovery promptly distinguished Bukit Bunuh as a site of sophisticated stone tools, thus refuting the Movius Line Theory (Movius 1944) which states that Southeast Asia had only 'chopper-chopping tools' without hand axe technology.

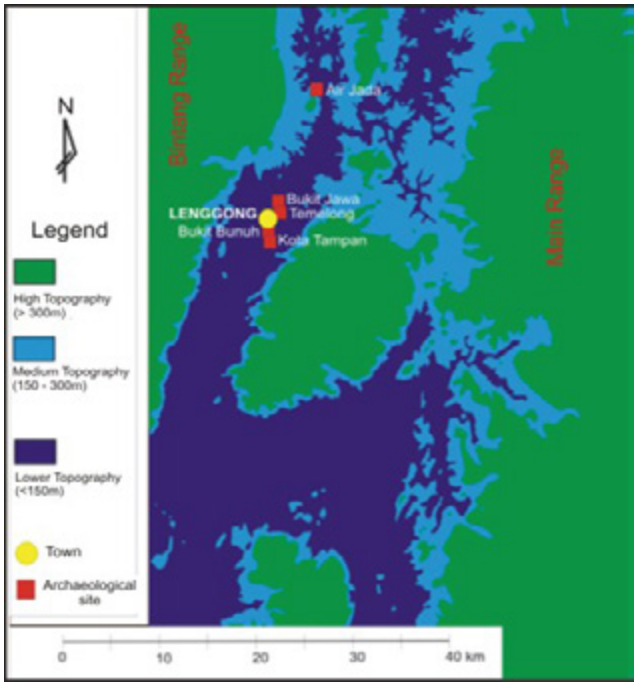


Figure 2. Bukit Bunuh and the other sites in Lenggong Valley are situated between the Titiwangsa and Bintang mountain ranges. Map by Jeffrey Abdullah 2009, after 1970 topographic map sheets 30 and 41 by the Malaysia Department of National Mapping.

Figure 3. Hand axe from Bukit Bunuh. Photos from Mokhtar Saidin (2006a).

Paleoenvironmental reconstruction of Bukit Bunuh suggests that the area occupied by hominins was near a lake at one point, as also seen at other sites in Hulu Perak (Mokhtar Saidin 2006b; Nor Khairunnisa Talib *et al*. 2010: 103). This site has also contributed to the advancement of absolute dating methods, specifically via optically stimulated luminescence (OSL), which also pinpointed another period of interest from the western part of the site, dating to 39,000 ± 2600 years ago (Mokhtar Saidin 2006a: 62).

Excavations

Two open sites about thirty meters apart have been excavated: Bukit Bunuh 2008 and 2010. Both sites are ancient terraces on the slopes of Bukit Bunuh. Two trenches were opened in 2008 (A1 and C6), and three in 2010 (F1, D5 and B) (Figure 4). These sites are located on a slope on the west side at 104-112 meters above sea level. The sites are located more to the east than previous excavations, being approximately 100 meters from Bukit Bunuh 2001, and 200 meters from Bukit Bunuh 2003. See Nor Khairunnisa Talib (2013) for more information about the excavations.

The excavation trenches (two-by-two meters) were placed based on the predicted thickness of the top layer, surface finds, and the height of the terraces containing artifacts. In 2008 and 2010 trenches were dug at different heights to recover paleoenvironmental evidence and indications of Paleolithic culture. The spit system was used during the excavations, with each spit being ten centimeters in depth. Each spit was carefully observed for association and classification of artifacts. The use of spit control facilitated observation of vertical distribution. The excavated soil was sieved to ensure that every piece of rock was recovered and analyzed. Tool-making technology and stone tool classification were assessed during the excavations, with measurement and recording of all artifacts recovered by spit (Nor Khairunnisa Talib 2013).

Sampling of soils and sediments took place for soil analysis, palynology and dating. Soil analysis included determination of pH level and soil composition. Palynological analysis aimed to reconstruct the paleoenvironment of the site at the time(s) it was occupied, by analyzing spore and pollen evidence. Sediment dating was carried out using the OSL method, with samples sent to the Korea Basic Science Institute laboratory in Seoul (Choi 2015).

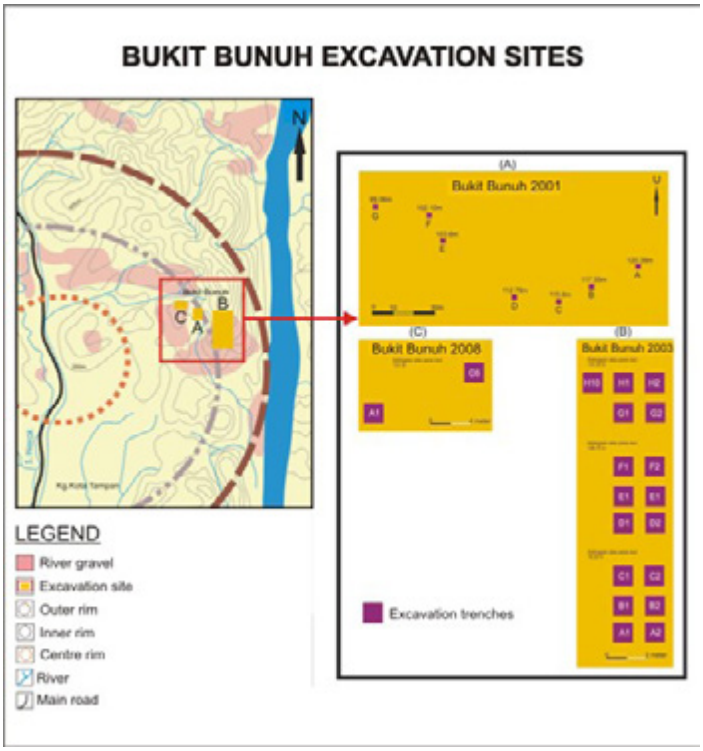


Figure 4. Excavation sites in the Paleolithic complex of Bukit Bunuh. Images by Nor Khairunnisa Talib (2013, after Mokhtar 2006a).

The results obtained from the excavations indicated that the respective trenches at Bukit Bunuh 2008 and Bukit Bunuh 2010 have both differences and similarities with regard to artifact types and association, thickness of the artefact-bearing layers and stratigraphy. One difference is in altitude, as the terrace excavated in 2008 stands at 103 meters above sea level, while that in 2010 is at 98-101 meters above sea level.

Excavations found that both sites functioned as workshops for making stone tools, based on a clear association between equipment tools (knapping tools) and stone tools (knapped tools), as well as the debitage (waste products) left behind. This association, and the fact that some artifacts could be conjoined, suggests that the sites have remained *in situ* (Nor Khairunnisa Talib 2013).

The results of artifact assemblage studies

Stone artifacts and natural rocks were segregated during laboratory analysis; the artifacts were then divided into three main groups: tools, stone tools and debitage. The Bukit Bunuh 2008 site produced 52,460 artifacts, and Bukit Bunuh 2010 yielded 50,451 artifacts (Figure 5). At both sites the artifacts discovered were mostly debitage, showing that both functioned as workshops for stone knapping. The most numerous types of stone tools discovered at both sites were flaked tools (Figure 6).

Observations on the association of the stone artifacts indicate several differences between the excavation trenches at the two sites. At Bukit Bunuh 2008 the lithics in association are cores, anvils, flaked tools, pebble tools and debitage. The use of anvils seems less essential in the association. This may be due to the small number of available cobbles which were suitable for use as anvils. Excavations at Bukit Bunuh 2010 unearthed several cores, hammerstones and anvils believed to have been used to produce flake tools and pebble tools.

The raw materials used for knapping were roughly of the same type at both sites: suevite, cherty metasediment, quartz and quartzite (Mokhtar Saidin 2010; Nor Khairunnisa Talib 2013). In addition to the use of cobbles, the use of quartz pebbles was also identified. Typically, pebbles were used as anvils and chopping tools. Observations made on the association and types of artifacts, in addition to the stratigraphy for all trenches, indicate the possibility that the sites belonged to different time periods.

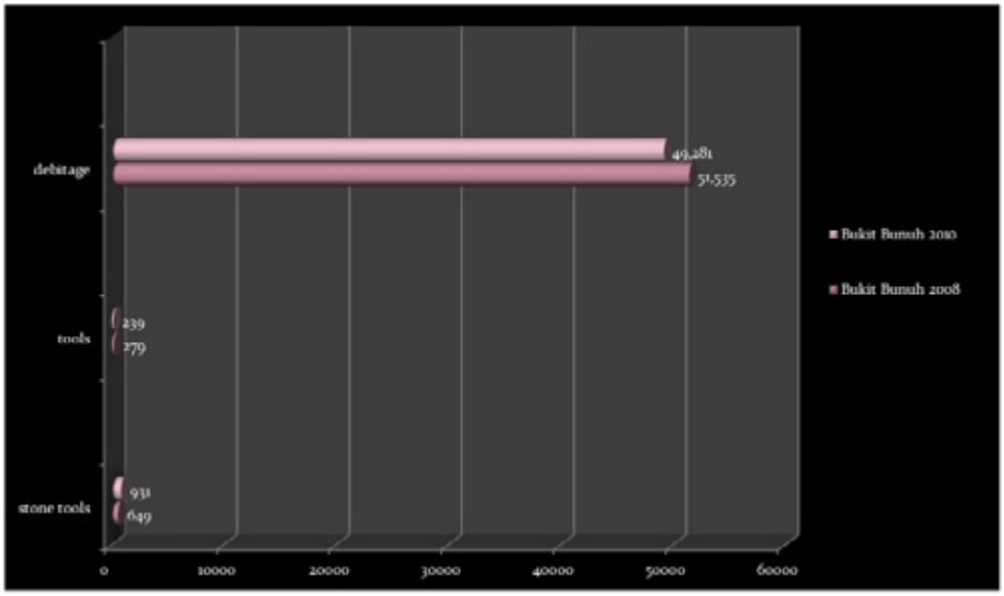


Figure 5. Numbers of lithic artifacts found in Bukit Bunuh 2008 and 2010. Plot by Nor Khairunnisa Talib (2013).

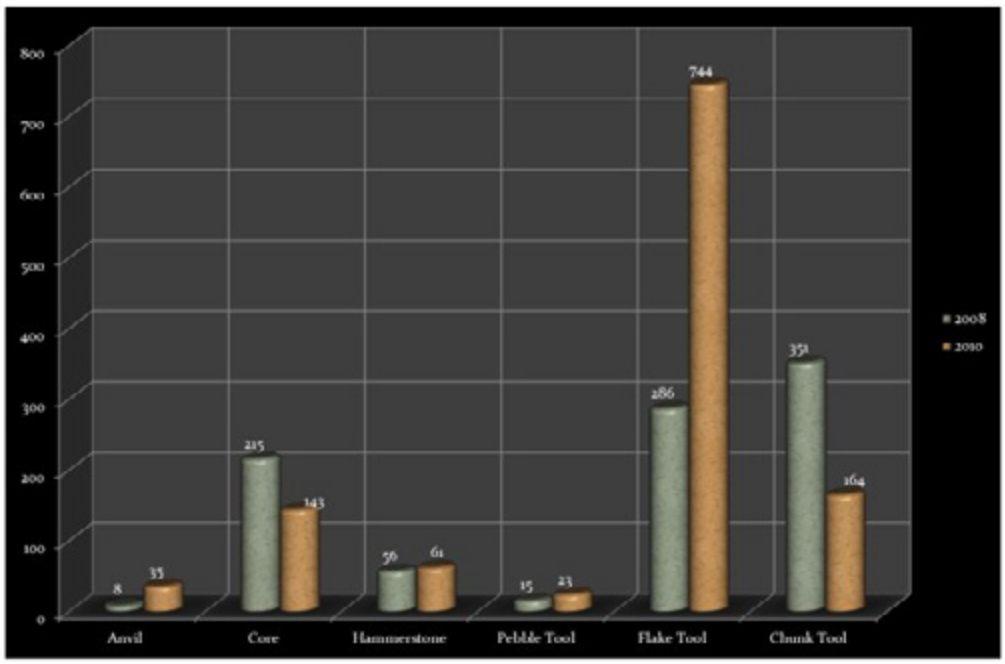


Figure 6. Comparison of stone tool types found at the sites. Plot by Nor Khairunnisa Talib (2013).

The excavation trenches did not produce the same overall assemblage, although both sites produced *in situ* evidence of Paleolithic culture.

Stratigraphy

Despite being at different altitudes, both excavation sites were found to have similar stratigraphy: a disturbed upper layer, an intact upper layer, a cultural layer, a base layer and a laterite layer. The cultural layers have similar thicknesses (fifty to sixty centimeters). For trenches A1, C6, D5 and B, the upper layer was disturbed by oil palm planting activities. Trench F1 had a relatively thicker upper layer compared to the other trenches (Figure 7). Despite the overall similarity, variations in the thickness of each layer were clearly visible, especially the cultural layer. The cultural layers in trenches A1 and C6 (Bukit Bunuh 2008) (Figure 8) were much shallower than the ones on the 2010 site.

In terms of soil composition, it was found that the cultural layers in the 2008 site contain more sand, less silt and more iron oxides, giving the soil a reddish tint. Geomorphological indicators are discussed below.

Dating

Soil samples from trenches C6, F1, B and D5 were sent for OSL dating. OSL was determined to be the most suitable way to determine the age of the sites, as the open sites in Lenggong Valley have no organic materials for dating; the only material available for dating was the soil itself. OSL dating is done by determining the length of time that has passed since mineral grains in the sample have been exposed to sunlight. Usually these methods require quartz or feldspar minerals as samples (Liritzis *et al.* 2013). Samples for OSL were taken at three different depths in each profile: the layer above the cultural layer, the cultural layer itself, and the layer underneath the cultural layer. Based on the results of OSL dating, the cultural layer at Bukit Bunuh 2008 site is estimated to be around 270,000 ± 4000 years old, while that at Bukit Bunuh 2010 is estimated to be around 490,000-550,000 ± 2000 years old (Table 1). The OSL dating agrees with the impression of the sites being occupied at different times. OSL dating is said to be limited to identifying up to 350,000 years ago, although some claim that the limit is up to 500,000 years, or even around 800,000 years ago (Wang *et al.* 2006: 98). The dates obtained place the two Bukit Bunuh sites at different times in the Middle Pleistocene.

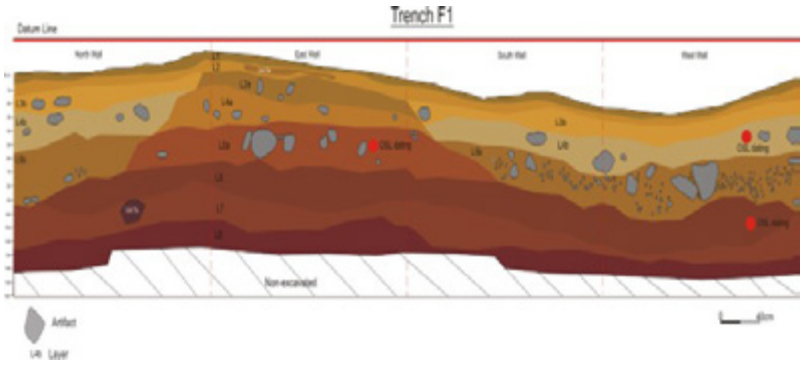


Figure 7. Stratigraphy of trench F1, Bukit Bunuh 2010. Image by Nor Khairunnisa Talib (2013).

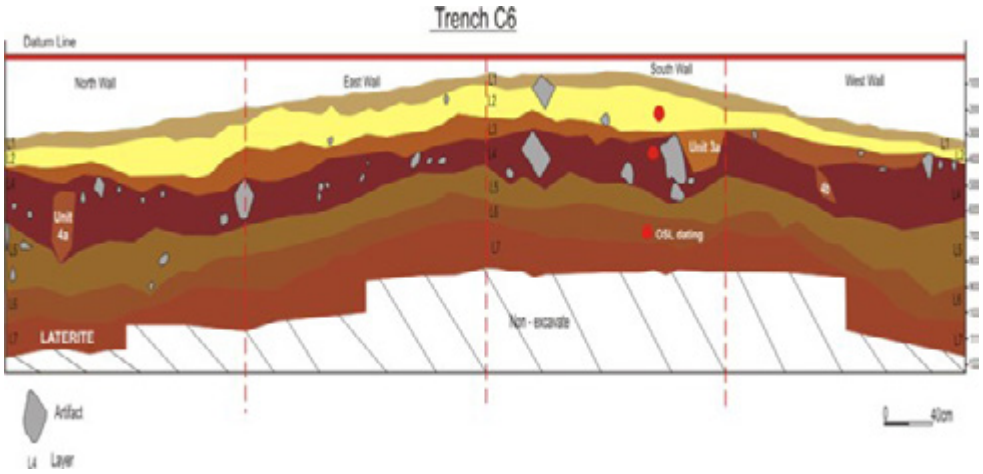


Figure 8. Stratigraphy of trench C6, Bukit Bunuh 2008. Image by Nor Khairunnisa Talib (2013).

Lithic classification

Lithic classification of finds from Bukit Bunuh 2008 and 2010 was done in accordance with that from other sites in the area (e.g. Zuraina Majid 1989a and b, 1997; Mokhtar Saidin 1997a and b; Hamid Isa 2007). This classification divides the recovered stone artifacts into three main groups, as mentioned above: equipment used to make stone tools, stone tools and debitage (Figure 9). All lithic artifacts discussed here were found *in situ* in trenches A1, C6, F1, D5 and B.

Lithic analysis was done by site, owing to the huge difference in age, but uses the same basic classification system. Knapping tools were further classified into three smaller categories: anvils, cores and hammerstones. Stone tools were further divided into flake tools, pebble tools and chunk tools. Our general observation is that debitage makes up most of the assemblage by number (97%), followed by stone tools (2%) and knapping tools at (1%) (Table 2).

Stone tool-making technology

Based on lithic analysis it was discovered that the early humans at the Paleolithic stone tool workshops found at both sites were using similar knapping techniques. The workmanship involves direct percussion, indirect percussing, edge-flaking techniques and the selection of suitable raw materials. The knapping techniques are also similar to those seen at other Paleolithic sites in Lenggong Valley such as Kota Tampan 1987 (Zuraina Majid 1989b), Kota Tampan 2005 (Hamid Isa 2007: 160), Bukit Jawa (Zuraina Majid 1997: 49), Temelong (Mokhtar Saidin 1997a: 85) and Lawin (Mokhtar Saidin 1997b: 354). Identification of stone tool technology is based on the association between the stone anvils, cores and hammerstones in producing stone tools. Direct percussion involves breaking up the stone by directly striking it with a hammer stone or slamming the rock onto an anvil. Indirect percussion involves the use of an anvil or the thigh of the knapper as a base for stone flaking using a hammer

Table 1. Dating of the trenches at Bukit Bunuh

Site	Trench	Depth	OSL date (years ago)
Bukit Bunuh 2008	C6	12 cm	90,000 ± 2000
		32 cm	270,000 ± 4000
		60 cm	320,000 ± 2000
Bukit Bunuh 2010	B	62 cm	490,000 ± 2000
	F1	61 cm	550,000 ± 2000

Figure 9 Lithic classification scheme used at Bukit Bunuh 2008 and 2010. Image by Nor Khairunnisa Talib (2013).

stone, while edge shaping is the process of flaking stone tools to create sharp edges (e.g. Andrefsky 2005).

Table 2. Lithic classification from Bukit Bunuh 2008 and 2010, by number of finds

	Bukit Bunuh 2008	%	Bukit Bunuh 2010	%
Stone tools	649	2	931	2
Tools	279	1	239	1
Debitage	51,535	97	49,281	97
Total	52,463	100	50,451	100

From field observations and analysis of stone artifacts, it was found that cores or preforms dominate both excavation assemblages (Nor Khairunnisa Talib 2013). The abundant use of these core stones may be due to the rich source of raw materials available on the sites, with impactites being scattered very closely to and in large quantities around the knapping workshops. One of the dominant materials for cores in the assemblages is impact quartz. Although preforms made of quartz were also widely used, they did not appear to yield the desired flakes compared to the cherty metasediment material used, perhaps because quartz is usually difficult to shape, as the material's grains affect the way it cracks (Holdaway and Stern 2004: 24). However, minimal use of hammer stones was found compared to usage of other tool stones. It is possible that both excavation sites were far from pebble sources but were near meteorite impactite sources which provided larger raw materials in the form of blocks and chunks. This may have resulted in minimized hammerstone use, as the available raw materials did not fit the criteria required for a hammerstone, which must be rounded and somewhat oval-shaped.

Stone tools found at the workshops at both the excavation sites were dominantly flake tools and 'chunk' tools. Pebble tools were found only in small quantities, perhaps due to the river deposit source being located far away from the workshops, or to it having an inadequate quantity of pebbles. Paleolithic societies of the region were more apt to use the nearest available raw materials in relation to their stone tool workshops. In fact, they were found to have made maximum use of the cherty metasediment rocks in the surrounding area, based on the finding that core stones initially used for a different purpose were used again as 'chunk' tools.

Raw material

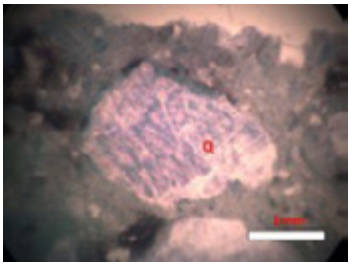


Figure 10. Cross lamella in a quartz mineral grain (center of image, quartz). White bar is 1 mm long. Photo: Nor Khairunnisa Talib (2013).

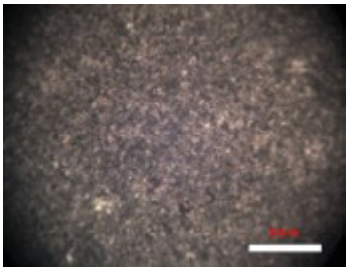


Figure 11. Fine mineral in cherty metasedimentock. White bar is 1 mm long. Photo: Nor Khairunnisa Talib (2013).

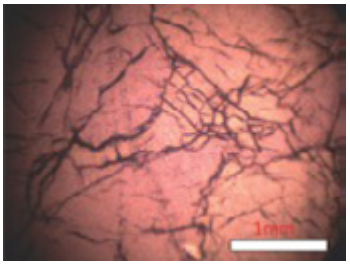


Figure 12. Quartz mineral with many cracks. White bar is 1 mm long. Photo: Nor Khairunnisa Talib (2013).

From the aspect of raw material usage, the identified artifacts consist of diverse raw materials, as noted above: cherty metasediment, suevite, quartzite and quartz. Analysis of raw materials shows that both sites used all of the aforementioned either as preforms for knapping or as tool stones. However, the raw materials found at Bukit Bunuh are different from those at other Paleolithic sites in Lenggong Valley, as minerals such as quartz and quartzite were also common choices for raw materials. This is because the rocks found in Bukit Bunuh were transformed into new rock types, as a result of the meteorite impact event. Rapid metamorphism in an impact event created intermittent lamellae of quartz minerals in the suevite (Figure 10). The resultant rock is very hard because of sintering of the original rocks under extremely high pressure and temperature. Cherty metasediment here is interpreted as an impactite resulting from shock metamorphism, which transformed the original rock giving it chert-like characteristics (e.g. Vernon and Clarke 2008). Results from petrographic studies show that these rocks contain very fine granules as well as microcrystalline minerals and iron oxides (Figure 11). The quartz probably existed as veins in local rocks and may have experienced metamorphism; it has fissures lacking a specific direction and there is also evidence of sutures suggesting that metamorphism occurred (Figure 12). Metamorphic qualities in the quartzite rocks of Bukit Bunuh include sintering to other suevite rocks and impactites.

In summary, the Paleolithic people of Bukit Bunuh utilized a variety of lithic raw materials for production of stone tools; these were frequently meteorite impactites, which appear to have been favored over river cobbles (Table 3 and Figure 13); most of the tools were made of cherty metasediment and quartzite, probably chosen due to their durability and ability to produce sharp edges. For example, cherty metasediment is a microcrystalline rock type which is difficult to break, easy to shape into sharp edges, and produces flat or relatively flat surfaces (Whittaker 1994: 67). Quartz was also turned into stone tools, although it was probably less desirable because it is generally difficult to knap, as the matrix contains cracks which affect the grain fractures (Holdaway and Stern 2004: 22). The preforms are usually oval or circular pebbles. Although the study site is not adjacent to sources of river pebbles, and we tend to see local material used for tools, ancient people still appear to have preferred anvils made of pebble stones.

Table 3. Raw material of tools and tool-production lithics at Bukit Bunuh 2008 and 2010

Raw material	Anvils	Cores	Hammerstones	Flake tools	Pebble tools	Chunk tools
Quartz	2	229	37	21	9	133
Suevite	28	105	37	76	6	64
Quartzite	1	72	27	298	12	134
Cherty metasediment	0	139	9	447	10	215

Paleoenvironment

The Middle Pleistocene Paleolithic societies in Bukit Bunuh were likely to have settled along a lake shoreline. This interpretation is based on the terraces upon which the stone-tool production sites were found, which are parallel and level to terraces found on the opposite hills (Figure 14). Paired terraces can only come to existence during long periods of low activity and are a frequent feature of lake basins. The existence of paired terraces may indicate that the water level declined abruptly and significantly at particular times (Tjia 1987: 70; Dincauze 2000: 210). Reconstructing the position of the terraces as they must have seemed during the period Bukit Bunuh was occupied by the Paleolithic societies, the area was shaped like a cape.

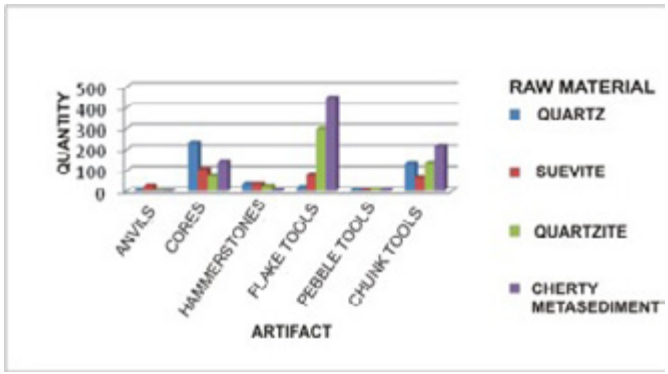
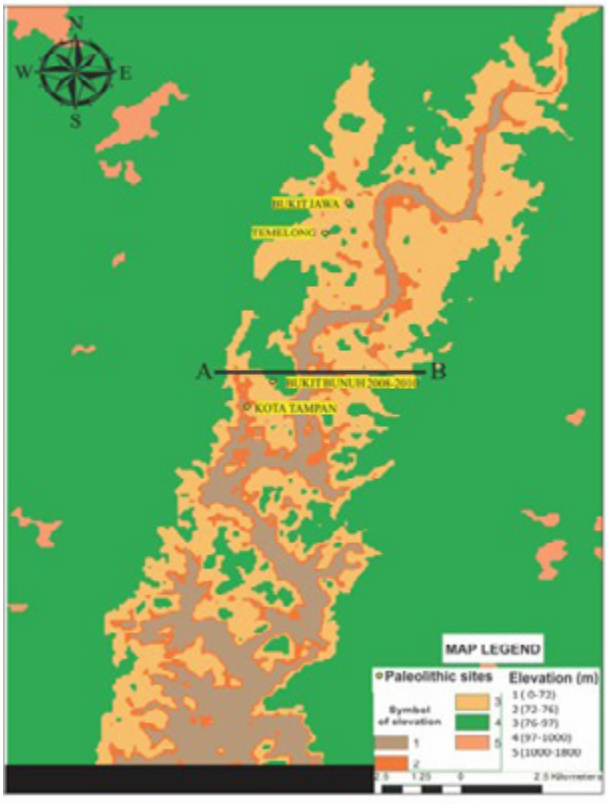


Figure 13. Comparison of raw material in the tools and tool-producing lithics. Plot by Nor Khairunnisa Talib (2013).



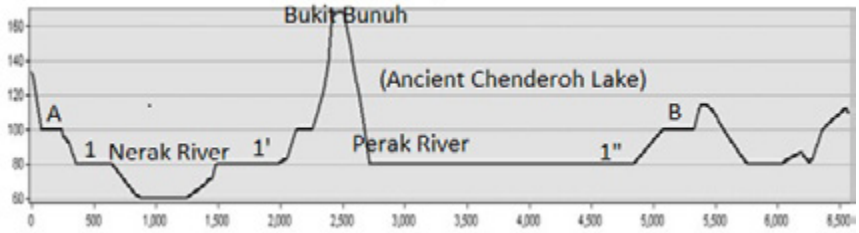


Figure 14. Landforms at Bukit Bunuh, and interpreted paired terraces (1, 1', 1"). Bukit Bunuh appears to be on a headland/cape topographically.
All figures made by Nor Khairunnisa (2013).

Soil and sediment stratigraphy at the excavation sites shows that the deposits before and after the settlement layers were composed of soil and were not deposited by water. These layers were likely to have been deposited by landslides or other slope erosion, as the excavation sites are on hill slopes and those hills are made of meteorite-impacted rocks; the possibility of landslides happening is high (Tjia 1993).

The possibility that Bukit Bunuh may have been at the edge of a lake during the Middle Pleistocene to Late Pleistocene is also suggested by paleoenvironmental analyses from other Paleolithic sites in the Lenggong Valley, e.g. Bukit Bunuh 2001-2003, Kota Tampan, Temelong and Bukit Jawa (Mokhtar Saidin 1997b: 250). It is possible that the proposed lake, known as ancient lake Chenderoh, irrigated the Lenggong Valley area during that period (Zuraina Majid and Tjia 1988: 130). Lake water levels would have differed considerably when these individual sites were occupied during their respective times.

Conclusion

The results of this study indicate that the Pleistocene Middle Paleolithic society in Bukit Bunuh was an advanced society with mental templates for knapping stone tools. Although they were producing a small variety of stone tools, the selection of suitable preforms shows that they were knowledgeable in lithic technology. This research site has made a new contribution to our understanding in terms of lithic technology and adaptation of the Paleolithic society. The lithic technology from the site supports the theory that Paleolithic societies in Southeast Asia produced many stone tool types with heterogeneous tool-making technology; the community had learned to choose the most appropriate material for making stone tools (Schepartz *et al.* 2000). The choice of texture is subtle; knowledge of the nature of the rock itself indicates that the people of the Middle Pleistocene were producing tools that were suited to their uses. This also supports other results in the area (e.g. Zuraina Majid 1989a and b; Mokhtar Saidin 1997a; Hamid Isa 2007).

As seen at the other sites within Lenggong Valley, ancient people appear to have adapted to life near a lake, and their settlement on this higher elevation point may reflect this. Further research should be done in the Bukit Bunuh area, especially in terms of experimentation and paleoenvironment (e.g. pollen), as the database for this important area needs more information. In addition to lithic technology, the community adaptation suggests that a lake environment was a major choice; most of the open sites in the Lenggong Valley are located on the shores of a lake, and it can be said that at Bukit Bunuh the existence of the ancient lake and the ease of access to basic lithic materials would have influenced the suitability of the site for occupation by the Middle Pleistocene Paleolithic community.

Metabolism, mythology, magic or metaphor? Animals in the rock art of Thailand

Lauren Winch

This paper introduces work exploring the specific social and environmental contexts of rock art in Thailand alongside considerations gleaned from rock art research in other parts of the world as a foundation for analysis of data gathered during fieldwork in 2011. This research examines the frequency, distribution, correlation and manner of faunal representations in Thai rock art, and uses this analysis to explore whether considerations of metabolism, mythology, magic and/or metaphor are relevant to the corpus, and by extension help to understand why the rock art of Thailand was produced.

Introduction

This paper introduces the findings of research into the significance of animal imagery within the rock art of Thailand. As of 2014 there were around 170 prehistoric and historic rock art sites known in Thailand, dispersed throughout the country (Sukkham 2011). The consensus is that the rock art was produced within the last five thousand years, and most of it relatively recently (e.g. Srisuchat 1996: 142; Higham and Thosarat 1998: 131; Shoocongdej 2002: 187; Sukkham 2011). This is based on several factors, including stylistic attributes of material culture in the art, and the combination of wild and domesticated fauna. Current estimates place the earliest agricultural systems in Thailand around 4,000 years ago based on evidence of rice cultivation, as well as the domestication of cattle, pigs and dogs (Kealhofer 2003: 76; Bellwood 2006: 109; Bentley *et al.* 2007: 301; Higham *et al.* 2011: 530). My PhD dissertation explored the potential social and environmental contexts of this rock art and the communities which may have produced it, taking into account the archaeological data alongside evidence from genetics, linguistics, biological anthropology and ecology (Winch 2013). This paper focuses on the animals within the rock art imagery, and my interpretations thereof.

My fieldwork was carried out in two study regions in Thailand: the coast of Krabi and Phang-Nga provinces in the southern peninsula, and inland in the north and northeast mountains (Winch 2013: 20-25). These regions were selected primarily for their reported concentrations of rock art (e.g. Sangwan 1987: 119; Higham and Thosarat 1998: 131-133; Sukkham 2011), and because they provided an opportunity to compare and contrast two quite different regions with different histories.

The peninsula is regarded as probably the most natural remaining region of the country (Higham and Thosarat 1998: 20), with evergreen tropical forest covering karst towers. The rock art appears to be limited to the western side of the peninsula, and predominantly in the modern-day Krabi and Phang-Nga provinces. The peninsula portion of the fieldwork revealed twenty-two rock art locations across fifteen sites, with an additional ten painted locations across five sites in the inland region (Figure 1).

Peninsula: fish, birds and daily life

The sites in the peninsula study region are clustered around the coastline, either on the coast itself or on mountainous islands a short distance into the bay. It stands to reason that marine resources would have played a key role in the survival of the people who inhabited the region in the past, as is also seen among the modern-day Chaole (Sarikabutora 1987: 149-150). A predominance of fish paintings documented in this corpus (Winch 2013: 216-241, 460) is therefore unsurprising, however these images appear to represent more than simply a primary food source for the people of the area. The frequent

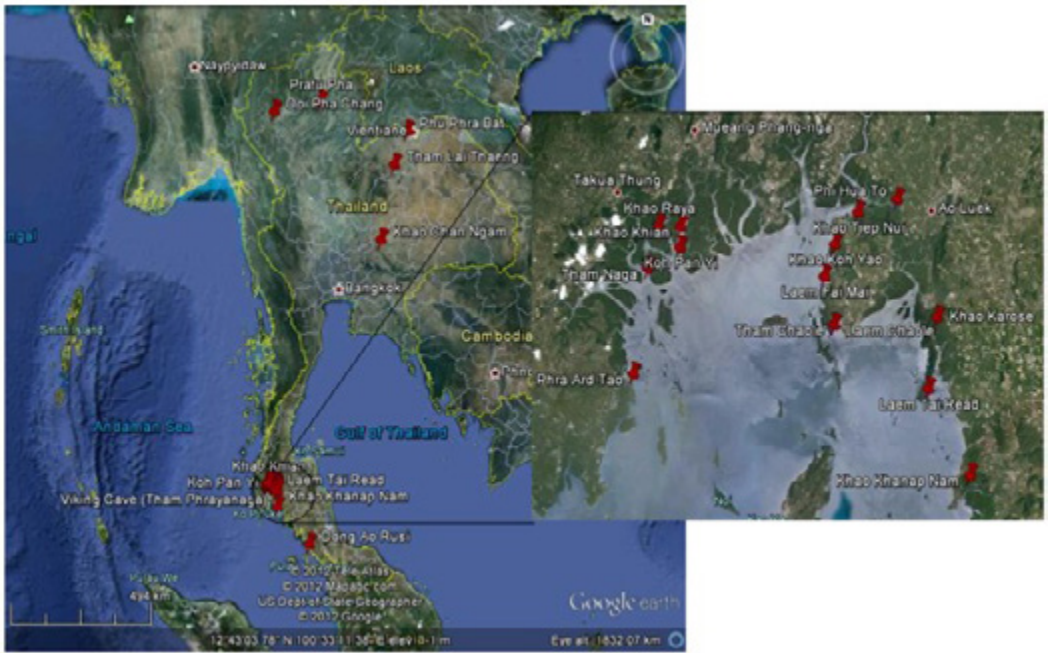


Figure 1. Map showing the locations of all sites recorded during fieldwork. Google Earth map modified by L. Winch.

association of fish images with anthropomorphic figures, the varied manner of their representations, and the elaborate detail on several fish paintings all attest to a greater significance than simple dietary – i.e. metabolic – requirements.

The prehistoric archaeological sites of Moh Khiew and Lang Rongrien both contain a variety of animal bones, with the Pleistocene levels from these two sites showing a strong focus on arboreal mammals and testudines, respectively (Anderson 2005: 141). This indicates that different communities focused on specific prey species dependent on local availability, cultural preferences and differential acquisition techniques. With the exception of fish and birds there are rarely more than one or two examples of any particular animal at any given rock art site. This suggests that different species were on an equal plane in whichever context the rock art represented or related to, whereas a rock art corpus based on metabolic considerations would presumably show a bias towards those animals which were integral to the diet (c.f. Winch 2013: 3-4). Indeed, the lack of correlation between the faunal repertoire in rock art and that of the archaeological record has been interpreted by some scholars (e.g. Vinnicombe 1976: 151; Clottes 2002: 86-90) as evidence that the animals in question have a greater significance than simple prey targets, and that the rock art therefore relates to cultural concepts above and beyond metabolic concerns. The fact that plants and shellfish appear to be absent from the painted record of Thailand further supports this (c.f. Winch 2013: 53, 408, 480); if the art were focused on purely metabolic concerns, one would expect these dietary staples to be at least present, if not abundant.

Perhaps the most common type of fish representation is where fish are seen in the hands or on the forearms of humans, although it must be acknowledged that there is an ongoing question of whether these figures represent birds or fish (e.g. Sarikabutora 1987: 144; Sukkham 2011) (Figure 2). The animal-on-forearm motif is especially common in the site of Phi Hua To, with small numbers also present in Tham Chaole, Khao Khian 2 and Khao Tiep Nui 1. Assuming that this fish classification for at least some of the forearm figures is correct, the questions of what and why then come to the fore. As forwarded by Sarikabutora (1987: 152) and Sukkham and colleagues (2011: 5), it is extremely likely that the paintings were produced by a community practicing a very similar way of life to the Chaole, with subsistence

strategies strongly focused on fish. While many of the paintings in Thailand's rock art corpus are undoubtedly related to more complex principles and beliefs than a representation of daily life, I suspect that these images of humans holding fish may be more directly correlated with day-to-day occurrences than the other paintings, as will be discussed below. They may still be imbued with a deep significance, however; survival would have been dependent upon successful fishing expeditions, and therefore this image may have had positive associations based on continuation of life and, by extension, the continuation of society as well.

As mentioned above, the animals on the hands or forearms of human figures have been argued to represent avian rather than aquatic creatures (e.g. Sarikabutora 1987: 144; Sukkham 2011). Assuming that fish were the mainstay of diet, if the animals are classified as fish then it could be argued that the rock art may be related to the everyday reliance on a successful catch. If they are birds, however, the explanation may be more complex, as birds do not necessarily have the same direct impact on daily life. They may have also played a crucial role in either a practical or perceptual sense. For example, they may depict fishing practices similar to those reported in China, Singapore and Japan, where seabirds are trained to catch fish for their owners (Sarikabutora 1987: 145). It is also possible that the portrayal of birds on the forearms of humans may relate to beliefs of protection; the Chaole perceive birds as 'protectors and guardians from danger' because their bodies are inhabited by the souls of their ancestors (*ibid.*: 149). Whilst there is no direct evidence that the Chaole are descended from the people who produced the rock art, it has been suggested that the belief systems of the painting communities may have been largely consistent with those of the Chaole (*ibid.*: 152).

The idea that birds may have been perceived as guardians by the painting communities is further supported by the widespread importance of birds in Southeast Asian folklore (e.g. Löffler 1966; Sarikabutora 1987), and the presence of avian-related imagery in rock art across the country. While humans and fish numerically dominate the rock art of the peninsula sites, it is the bird images that have received the most attention to detail. Birds also feature in the rock art of the inland region, with feathered head-dresses and 'tails' on human figures being present both in the sites recorded by this project and those documented by other scholars (e.g. Higham and Thosarat 1998: 131-132; Shoocongdej 2002: 199). Birds and bird-related imagery have also been documented on other items of material culture from prehistoric Southeast Asia, including bronze drums from Thailand, Vietnam and southern China (Löffler 1966: 5; Kanjanajuntorn 2006: 50-51).

Figure 2. Examples of the animal-on-forearm motif from Tham Chaole (top), Phi Hua To (bottom left) and Khao Tiep Nui 1 (bottom right). Photographs: L. Winch.

The long, curved beaks of many bird figures in the peninsula paintings are indicative of wading birds such as ibises or storks. There is no known record of these birds in the archaeological deposits from Thailand; this does not necessarily mean, however, that they were not preyed upon, as bird bones do not normally survive particularly well in archaeological deposits. These birds could also or alternatively have had some special social or spiritual salience for the prehistoric communities inhabiting the coastal mangroves of peninsular Thailand. One particular curved-beaked bird image specifically hints at symbolic salience, as it has been depicted with a spiral motif filling its body. This painting is at Laem Fai Mai, a site which also has a

large detailed fish image, two naturalistic stingrays, a four-legged anthropomorphic figure, and several indeterminate or geometric figures (Winch 2013: 216, 219-222, 325). This range of images highlights the complex interplay between the natural world and the artists' perceptions thereof. It is also suggestive of multiple inputs into the rock art and is one of the key sites suggesting that both individual and collective identities play a complementary role in the production of rock art 'palimpsest' sites.

Peninsula: 'palimpsest' sites: initiation and identity

This section focuses on the five sites studied which show the greatest degree of intra-site variation with respect to species, styles and color: Laem Fai Mai, Phi Hua To, Laem Tai Read, Khao Khian 2 and Khao Khian 3 (Winch 2013: 585-606, 610-614, 653-667). I have labelled these sites the 'palimpsest' sites, because they appear to consist of more than one different contribution (*ibid*.: 422-423). In some cases, this includes direct superimposition of images over one another, whereas others show an array of separate images throughout the site.

The variation in these sites is wide-ranging: from different species to different colors and different methods of depictions, with no discernible standardized chronology for the order in which particular species, styles or colors were added to the sites. This variation can therefore be argued to stem from individual inputs and may potentially have been related to life events such as puberty or initiation. This could certainly explain the wide variety of animals, styles, and artistic abilities, and also the repeated use of particular locales despite the availability of other rock shelters in the surrounding area which are objectively equally suitable for painting (c.f. Lewis-Williams 1974: 99; Vinnicombe 1976: 139). This may have been more likely to be a tradition rather than a strictly enforced rule, and one might imagine each image being a metaphorical representation of each individual who was adding his or her mark to the community, and so cementing his or her place within it. Where studied, hunter-gatherer communities in modern Thailand, including the Chewong (e.g. Howell 1989: 50) and Mlabrai (e.g. Trier 1981: 293), do not, however, appear to have any elaborate rituals associated with life history events such as puberty or initiation. I suggest that rock art may, however, have been a way of paying homage to an individual's role within the community in association with such life history events; perhaps it was not a grand, elaborate gesture, but rather relatively small-scale yet poignant testimony to both personal and collective identity.

With respect to the contents of the paintings in these peninsula rock art sites, the high degree of variation in species – including fish, birds, stingrays, lizards, monkeys, a dolphin, an elephant, a rhinoceros etc. – may be explained in a number of ways. It may simply be that each individual selects a creature of which he or she is fond, or which is believed to have a characteristic that he or she aspires to embody, such as bravery, strength or stealth (cf. Kristoffersen 2010: 265-266), or which may be their totem animal or spirit guide. Totemic associations between people and animals have been posited by Nash (2003: 127) for rock art in Borneo, therefore providing a precedent for this explanatory paradigm in the rock art of the wider region.

I have addressed the contentious issue of analogical reasoning in some detail elsewhere (Winch 2013: 161-176), where I argue that there can be merits of this approach so long as the analogies are used not as a direct comparison but rather as a springboard for interpretation, and as inspiration for asking new questions of the data at hand. With this in mind, there are ethnographic examples from other parts of the world where rock art has been linked to spirit guides. For example, initiates of the Klamath and Modoc peoples of western North America produce rock art which represents their individual spirit guides as encountered in animal form during their vision quests (Loendorf 2004: 205). Whilst there are no ethnographic precedents for vision quests in the Southeast Asian record, these or similar experiences have been documented across a wide range of hunter-gatherer groups (e.g. Keyser and Poetschat 2004: 121; Whitley *et al.* 2004: 226); therefore it is feasible that they were once part of the

cosmology and worldview of prehistoric communities in Thailand. Spirit guides do not necessarily need to be encountered during vision quests; they may reveal themselves through dreams or be 'seen' by a ritual specialist on behalf of an individual. For example, the Temiar hunter-horticulturalists who inhabit the modern-day Malaysian rainforest believe that during dreams the 'detachable, unbound head soul of the dreamer' meets with the souls of beings that could potentially become their spirit guides (Roseman 1993: 6). Among the Chewong there is a belief that only the 'cool' eyes of the shaman are able to see spirits and other 'personages' (Howell 1999: 133); it is possible that a similar belief system was present among the painting communities, and that shamans informed individuals of their spirit guides.

The idea of a world imbued with spirits is widespread across Thailand, with various forms of animism being present in different extant hunter-gatherer communities ranging from the Malay Peninsula (e.g. Howell 1999: 133) to the Mlabrai in northern Thailand (Trier 1981: 293), and across all of the hill tribes in the northeast of the country (e.g. Rashid and Walker 1975: 160; Walker 1975: 5; Chindorsi 1983: 187). I am therefore confident in the argument that the animal paintings in these palimpsest sites represented far more than a source of meat or an element of the local ecology; rather, they may have related to a conceptual connection between the individual and the beings portrayed.

Related considerations: human figures in the rock art

Of all the peninsula sites, Phi Hua To contains the most extensive array of paintings, with at least 200 images of humans, animals and indeterminate figures showing varying degrees of preservation (Sukkham 2011). Dotted in amongst these naturalistic and fantastical images is a class of anthropomorphic figures painted primarily in black, which display remarkable stylistic continuity in all elements bar one – the designs applied to the figures' torsos (Figure 3). It may be that these were produced alongside the animal images, or that one category was a forerunner to the other, and that while the basic tenet of individualized representation remained constant, the method of depiction shifted. The high degree of similarity between the anthropomorphic images may imply that they were produced predominantly by one individual, perhaps some form of religious specialist. This individual may even be represented by the well-known 'hawking figure', claimed by Sarikabutora (1987: 144) to depict a 'man dressed as a bird or decorated with a headdress made from cock or bird's feathers', which links back to the earlier discussion of the significance of birds and bird-related elements in the art and related belief systems of prehistoric Southeast Asia.

Therianthropes

The previous sections have introduced potential explanations for some of the human and animal figures in the rock art of peninsula, but what of those figures which combine elements of the two? Therianthropic figures such as the 'hawking figure' mentioned above may have related to ritual specialists. I am hesitant to use the word 'shaman' when there is no direct ethnographic data for the community in question, although it is quite possible that these ritual specialists performed similar roles to those labelled shamans among modern communities such as the Chewong (Howell 1999), Semang (e.g. Shoocongdej 2002: 189) and various hill tribes (Rawson 1967: 140; Rashid and Walker 1975: 161; Chindorsi 1983: 187).

The roles fulfilled by ritual specialists from a variety of rural communities across modern Thailand show a surprising degree of correlation, bypassing subsistence categories, ethnic backgrounds, and thousands of miles of terrain. One of the key roles of ritual specialists is to interact with beings from the spirit world, including ancestral beings and/or various malevolent and benevolent spirits which can interfere with the 'real' world, and also to protect and nurture essences roughly akin to a soul or a vital essence, which are an implicit and fundamental element of all living things. For many communities

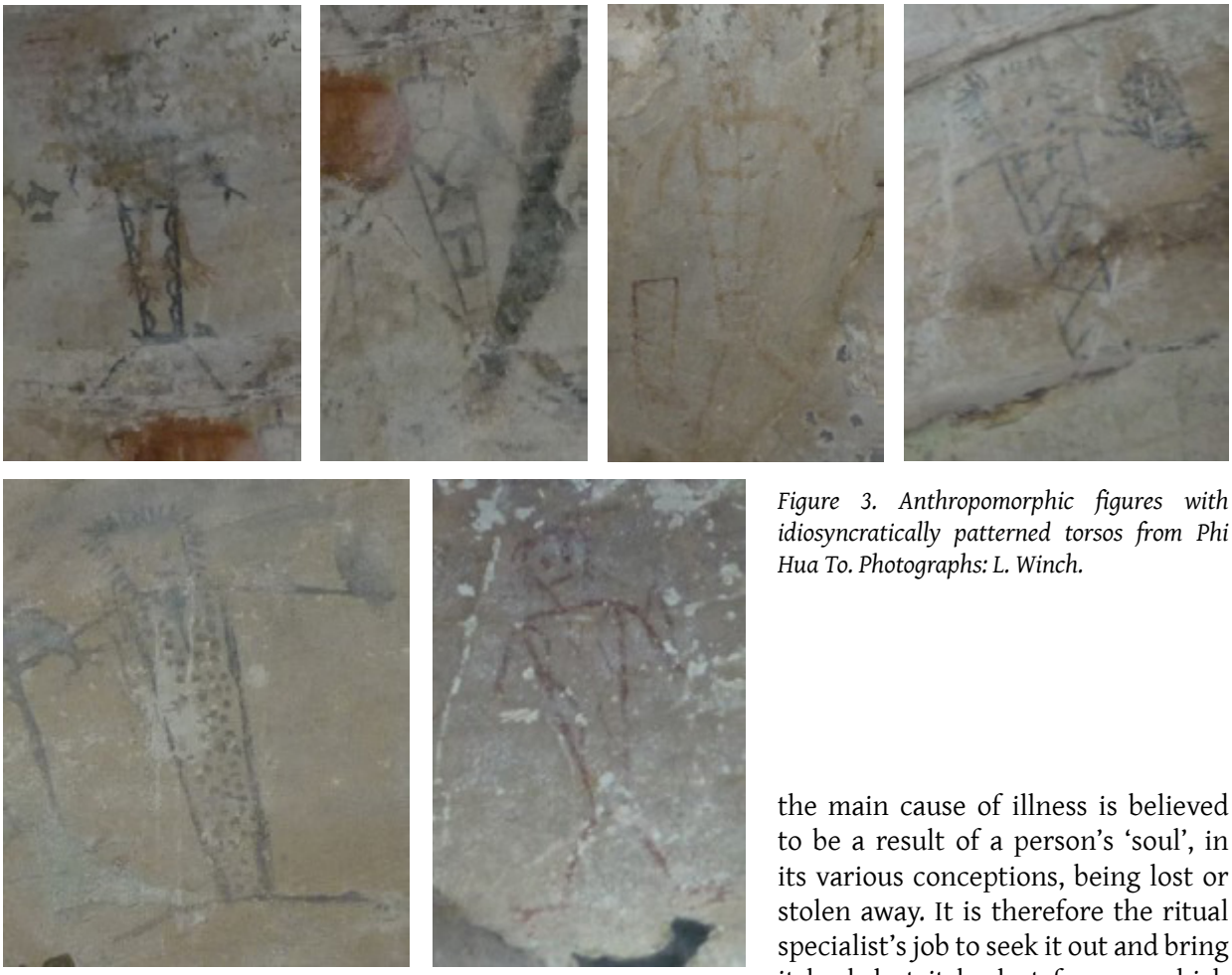


Figure 3. Anthropomorphic figures with idiosyncratically patterned torsos from Phi Hua To. Photographs: L. Winch.

the main cause of illness is believed to be a result of a person's 'soul', in its various conceptions, being lost or stolen away. It is therefore the ritual specialist's job to seek it out and bring it back lest it be lost forever, which would inevitably result in the death of the human body in which it previously resided (e.g. Beng 1975: 26; Kunstadter 1983: 138, 145; Larchrojna 1983: 170-171; Howell 1999: 133-134).

According to Shoocongdej (2002: 199), the presence of feathered head-dresses in the rock art of north-western Thailand was related to ritual behaviors which were quite widespread across the region. It may be that ritual specialists donned feathers as part of their ritual attire in order to help them achieve transcendence into the spirit world. Using the body parts or feathers of certain birds or animals may have been undertaken by individuals in prehistoric communities, such as in ritual costumes, in order for the wearer to identify with the spirit, the power or the core essence of the animal from whence they came. Whilst such beliefs have not been documented in Southeast Asia, similar explanations have been forwarded for a range of communities and this can be considered a possible explanation, albeit requiring more direct evidence before a strong argument can be forwarded. The donning of animal accoutrements as an integral element of ritual is sometimes tied in with a belief that ritual specialists can transform into animal form in order to undertake their journeys into the spirit world (e.g. Devlet 2001: 44; Dowson and Porr 2001: 171; Sutherland 2001: 138, 140); the animal costume may aid the process of transformation.

The notion of ritual specialists journeying to the spirit world to perform various social and spiritual activities has been documented in all known hill tribes in modern-day Thailand (e.g. Rawson 1967: 140; Jaafar and Walker 1975: 178; Rashid and Walker 1975: 161; Chindorsi 1983: 187), although there is no direct evidential link between these groups and the prehistoric communities who produced the art.

The importance of ritual specialists is extremely widespread across the region, and among the Semang hunter-gatherers of the Malay Peninsula the most influential individual is also the shaman (Shoocongdej 2002: 189; cf. Eliade 2004: 337-341). I argue elsewhere (Winch 2013: 452) that there is reason to believe the Semang can be considered the strongest analogue for prehistoric rock art-producing communities. This is based not only on the fact that they are known to have produced rock art in historic times (Faulstich 1988: 24; Mokhtar Saidin and Taçon 2011: 463), but also citing genetic evidence which indicates their presence in the Malay peninsula way beyond the dates for the rock art (e.g. Hill *et al.* 2006: 2488-2489), and further supporting linguistic evidence (Winch 2013: 471-472).

The concept of journeying to the spirit world may therefore help to explain the presence of therianthropic figures in the inland rock art of Thailand and may also have relevance for a number of figures in the peninsula sites. These include the aforementioned 'hawking' figure at Phi Hua To, a four-legged anthropomorphic-like figure at Laem Fai Mai (Winch 2013: 325), and also a theorized rhinoceros-human therianthrope at Khao Khian 3 (*ibid.*: 336-337). Such explanations should not be applied on a broad scale to all therianthropic figures in the peninsula rock art, however. A number of such figures are less likely to be ritual specialists, but rather a more personal identification with an animal or its spirit. For example, the cave sites of Laem Chaole, Phi Hua To and Khao Khian 1 all contain figures which appear to have both fish and human features. This conflation of features further attests to the significance of these animals in everyday life and survival and may also imply that the humans are identifying with the fish. This may be related to ideas of contagion and sympathetic magic principles or represent belief systems whereby a hunter or fisher identifies with his or her prey. The same principles may also explain the similarities between a lizard and a human figure side-by-side in Khao Khian 3 (Figure 4).

I am confident in the taxonomic classification of these figures as lizard and human respectively, yet the color, style, stance, and details of the fingers/claws show remarkable consistency between them (cf. Winch 2013: 273-274). It may therefore be that the iconographic equivalence represents a strong sense of identification and empathy between the two figures. Ethnographic precedents for strong associations between humans and animals include ritual and metaphorical alignments between men and marine species in the eastern Solomon Islands (Waite 1989: 321), people and fish in the mythology of the Australian Aborigines of western Arnhem Land (Taçon 1989: 243), and also the southern African San with eland antelope (Guenther 1999: 176). These cases predominantly relate to a community-wide affiliation with particular species, demonstrating the extent to which metaphorical connections between humans and animals can pervade society and be perceived as compelling and absolute.

Figure 4. A lizard figure (left) and a human figure (right) side-by-side at Khao Khian 3. Photograph: L. Winch.

Inland: collective themes and communal scenes

In stark contrast to the eclectic mix of species found in the southern sites, the majority of sites in the inland study region only feature one different type of non-human animal per site (Winch 2013: 400-401, 428). For example, both

Tham Chang and Doi Pha Chang were home only to their namesake *chang*, the elephant. The latter of these sites sees white images of elephants and also humans superimposed over earlier, faded red motifs, a phenomenon which is also reported from the site of Non Sao Aei in Phu Phra Bat, where the newest layer of white painting consists only of two elephant figures (Information panel at Phu Phra Bat Visitor Center; c.f. Winch 2013: 287).

Pratu Pha is the only inland site which unequivocally features a range of different animals, although even here the animal repertoire is dominated by deer and/or bovids. Tham Lai Taeng comprises a dense array of images, yet the only certain species identification for this site is a dog. Likewise, the only definite non-human animal image at Khao Chan Ngam is also a dog. The remaining inland sites surveyed consist exclusively of human, geometric or indeterminate images (Winch 2013: 214-216, 400-401, 428-447).

It therefore appears that individuals here were not identifying with animals – or spirits they embodied or envisioned – in the same way as they were in the peninsula. Like the peninsula sites, however, it does appear that different categories of rock art sites exist, which is hardly surprising considering the vast distances involved between sites. That being said, there are some remarkable comparisons which can be made between certain sites, such as the stylistic similarities evident in the portrayal of anthropomorphic figures in Khao Chan Ngam and Tham Lai Taeng, despite the fact that they are separated by around 200 kilometers (Winch 2013: 429).

The common themes inherent in the rock art of the inland sites are discussed below, where relevant comparisons and contrasts with the peninsula dataset are drawn. I argue that, in general, the rock art of the inland sites represents a collective affair, and while the community may have been present at the time of production, and/or embodied within the significance of the art, the painting events themselves appear to have been largely undertaken by one individual at each site. Pratu Pha is likely to be an exception to this rule, and where different stages of painting have taken place this argument is extrapolated below to refer to each 'layer' rather than the site as a whole.

Ritual and community

Several of the inland rock art sites feature panels which suggest an impression of community, and unlike the peninsula sites there is genuinely a sense of scene. For example, the site of Tham Khon in Phu Phra Bat Historical Park features a procession of human figures along the base of the rock, in which all of the figures are facing the same direction and portrayed in identical style, size and color (Figure 5). While there are some small differences between individual figures, there does not appear to be any attempt to specifically differentiate any one figure from any other. The implication is that they were produced by one painter, and that the aim was to represent a group of people engaged in a shared experience (Shoocongdej 2002: 189). The procession element suggests that this may have had some kind of ritual connotation, and an explanation centered on some form of dance may be supported by the bent knees and splayed arms visible in a number of figures. This analysis is echoed in Shoocongdej's (*ibid*.: 192) discussion of another Thai rock art site, where 'Thai scholars suggest that the paintings at Tham Ta Dung depict a ritual procession; dancing possibly was part of the ritual'. Among extant rural communities in Thailand, the Mlabrai include singing and dancing as central components in many aspects of their social and cultural activities (Pookajorn 1985: 217), as do many of the hill tribes (e.g. Walker 1975: 12). The Chewong of the Malay peninsula, in contrast, only dance during funeral ceremonies (Howell 1989: 149). Indications of dance are also present at Khao Chan Ngam, where a well-preserved panel near the top of the main boulder contains a number of human figures; even though they are facing different directions and engaging in different behaviors, there is a definite sense of scene in this panel (Figure 6).

This is one of the few sites which contain explicit references to biological sex, not only in the human figures but also a dog with a penis. The dog is positioned directly above two seated figures facing one another. The figure on the right has been identified as a woman based on her prominent breasts, and the deliberate portrayal of a rounded stomach may be indicative of pregnancy. She has detailed fingers and hair, and is wearing some form of feathered tail appendage, which may have similar ritual associations to the bird-related ritual paraphernalia discussed previously (cf. Shoocongdej 2002: 199). Fine hair and finger details are also evident on the smaller seated figure on the left (Figure 6), which I assume to be a young man or boy. This assumption is based on a lack of breasts or tail appendage, and by the presence of what appears to be a quiver on his back. Immediately next to him is a large upright male figure – identified by his penis and also a 'kilt' which appears to be a stylistic trait of males at this site (Higham and Thosarat 1998: 131) – bearing an identical quiver-like object on his back, along with a bow which has just released an arrow in his hand. The majority of identifiable figures at this site are male, identified by the presence of 'kilts' and/or penises. Perhaps surprisingly, the figures discussed previously show the only direct reference to hunting paraphernalia in this site. However, there are two separate male figures holding some form of stick, which could potentially represent a spear. While the modern-day Mlabrai hunter-gatherers of northern Thailand do use spears for hunting (Pookajorn 1985: 215), the Chewong of the Malay Peninsula report that until recently the only weapon they used was the bow-and-arrow (Howell 1989: 25). The sticks in the Khao Chan Ngam paintings are held upright and do not have any obvious tapering towards the end, so there is no specific evidence to suggest that these depict spears.

Figure 5. A procession of human figures at Tham Khon. Photograph: L. Winch.

Overall it appears that the panel does not depict a 'hunting scene' *per se*, and the estimated age of these paintings at 3000 to 4000 years old (Information panel *in situ*; Atthasit Sukkham, 20 June 2011, pers. comm.), makes it unlikely that this is a conflict scene, as there is currently no evidence for violent conflict in the region prior to the Iron Age (Higham and Higham

Figure 6. A collection of figures at Khao Chan Ngam. Photograph: L. Winch.

2009: 138), which began in the first millennium BC (Solheim 1970: 153). Whilst it could potentially be argued that this image may represent the first evidence of violent conflict in earlier times, there is not currently sufficient evidence to support this. The question then arises: why was a man firing an arrow in the middle of this scene?

Looking at the other images, there are a number of figures displaying postures indicative of dance with their arms being raised in various positions (Shoocongdej 2002: 199). It is my interpretation that this scene reflects a communal event which may have been related to hunting, i.e. a ritual performed before the men set off on a hunting trip to keep them safe from malicious spirits, or to bring them hunting success. The lack of evidence for slain animals or prey species in the scene suggests that this ritual took place before rather than during or after the event, although it is interesting to note that dancing is a key component of post-hunt celebrations among modern-day Mlabrai hunter-gatherers (Pookajorn 1985: 217).

Hunting

There are a number of other examples from the inland sites, however, which do appear to actively depict hunting practices. These are concentrated at Pratu Pha, a vast site dominated by an inordinate number of handprint motifs, which once again hint at a sense of community and cooperation. Pratu Pha is perhaps the most fascinating of all the sites discussed here, as it consists of a very different array of images, scenes and styles, yet there is still a sense of cohesion across the site. There are a number of small collections of images and motifs, however the two clearest examples of scenes both relate to hunting. The first of these comes from the aptly named 'Cliff of Hunting' and shows either bovids or deer being pursued by humans and a dog (Figure 7). On first observation it may appear that this is a depiction of an everyday event. However, on closer inspection it becomes apparent that there may be something more intangible going on. For example, in the immediate vicinity of the hunting scene there is a therianthropic figure which appears to combine a human physique with insect or crustacean-like features – including forked endings to its arms and an extra pair of limbs – which is painted in the same color and

Figure 7. A 'hunting scene' from Pratu Pha. Photograph: L. Winch.

Figure 8. A scene from Pratu Pha showing at least one bovid surrounded by humans. Photograph: L. Winch.

general style as the other figures. This suggests that either the hunting scene is conceptual rather than literal, or that it is a true hunting scene with some form of spirit or religious specialist in therianthropic form influencing the success of the hunt in a positive or negative capacity.

The second key hunting scene at Pratu Pha can be found at the 'Cliff of the Ox', where a stylistically dissimilar scene shows a collection of human figures with sticks or spears surrounding at least one bovid (Figure 8). Inspection of the rock surface at the site suggests that much of the older art has flaked away, exposing a new surface of rock underneath; it was on this new surface that the 'ox' scene was painted (Figure 9). This places it at a relatively recent stage of painting, and it is certainly newer than at least some of the other animal paintings at this site. The implications are either that the site was returned to by an agriculturalist group who included hunting or animal sacrifice in their ritual behavior repertoire – perhaps in order to tap into the power or potency of the locale as attested by the extensive rock art here – or that it represents a hunting scene from a later group who were continuing to practice hunter-gatherer lifeways in the face of incoming changes.

The notion of tapping into the power of the place may also be an explanatory factor for the preponderance of handprints in the original layer of paintings at this site. The application of handprints to rock surfaces has been related to the notion of the rock surface as a membrane between the real world and the spirit world in various rock art-producing communities across the world (e.g. Lewis-Williams 2002: 216-220). This may imply that Pratu Pha has long been a focal point for ritual activities including, but not necessarily limited to, the production of rock art, and that the art which adorns its surface may have been at once a source of its power and also a reflection of it.

Superimpositioning

Superimpositioning, the act of layering different phases of painting upon one another, has long been of interest to rock art researchers (e.g. Lewis-Williams 1974: 93-103; Bahn and Vertut 1999: 64-71; Mitchell 2002: 206). It hints at a continued salience of the location, the rock surface, the images themselves, or a combination of all three elements. Whilst it is entirely possible that it is coincidental, the majority of cases of superimposition within the dataset discussed here appear deliberate, based on the fact that other objectively suitable surfaces nearby have been left unpainted.

In the inland sites, superimpositioning can be seen at Doi Pha Chang, Pratu Pha, Tham Chang and Tham Lai Taeng (Winch 2013: 441-446). It appears to be the less cohesive collections of images that receive the highest degree of superimpositioning; I have not found any examples of distinct 'scenes' either above or below other phases of paintings. The communal scene at Khao Chan Ngam, for example, appears to be an isolated painting event. Likewise the series of bovids at Tham Wau and the procession of humans in the neighboring site of Tham Khon stand alone as collective entities, and while some of the human figures in the latter do overlap in places, this is likely to have been deliberately portrayed in an attempt to demonstrate the nature of the collective ritual activity in which they were engaged. The hunting scenes at Pratu Pha also lack superimpositioning, despite the fact that many sections in this site are so densely painted that individual images become indiscernible in places. This would therefore suggest that perhaps these 'scenes' had some special salience, and that perhaps they were not to be disturbed.

Where superimpositioning does occur, it takes place to vastly different degrees. From the dense palimpsest of Pratu Pha we move to the two-stage rock art site of Tham Chang in Phu Phra Bat Historical Park. Here, faded geometric images attributed to around 3000 years ago are dotted across the surface; however, they are overshadowed by an impressive fine-line elephant painting thought to have been added in the nineteenth century AD (Information panel in situ; image available in Winch 2013: 574). Although there is not a significant degree of overlap between the older images and the 'new'

Figure 9. The Cliff of Hunting at Pratu Pha, with the different stages of painting identified. Photograph: L. Winch.

elephant, there was also no effort made by the later painter to avoid these previous additions to the rock surface. It may be that they were considered inconsequential and were therefore painted over with little regard, or the opposite may be true and the superimpositioning rather reflects some form of power of place. With reference to the various rock art sites at Phu Phra Bat, Higham and Thosarat (1998: 132) conclude that '(the) numerous superimpositions over faded earlier motifs suggest that rock faces of this region attracted artists over many years'. Similarly, the newer phase of painting at Doi Pha Chang was executed on the only boulder on the mountain found to contain traces of previous red paintings, despite numerous other boulders with objectively suitable surfaces being available (Winch 2013: 441-443).

At Tham Lai Taeng, the fact that both naturalistic human figures and distinctly unnatural conflations of human and animal characteristics are displayed side-by-side, overlapping and at varying angles and positions suggests that all of these figures are tied up in some complex web of beliefs and perception (Figure 10). They do not form a straightforward 'scene' in the same sense as the groups at Khao Chan Ngam or Pratu Pha do; however, they could still potentially be considered parts of the same whole. I am hesitant to fall into the trap of attributing rock art to 'shamanistic' interpretations, following the backlash to the over-application of this hypothesis (Solomon 2000: 77; Bahn 2001: 75; McCall 2007: 227). However, the images at Tham Lai Taeng in particular do suggest that they are related to ritual and spiritual experiences which may be associated with entry into altered states of consciousness, however induced. Such experiences can include somatic hallucinations, and also the perceptual transformation into or blending with animal form (Dowson and Porr 2001: 171) and would explain many of the unusual features in the human-like figures at this site. The presence of at least one human figure which appears to be playing a musical instrument could further support this interpretation, as entering into altered states of consciousness can be assisted and encouraged by rhythmic music (e.g. Devlet 2001: 47). For example, among the Hmong of northeast Thailand, a shaman's entrance into trance is facilitated by the beating of a gong (Chindorsi 1983: 189), and for the Temiar of the Malaysian rainforest 'songs are paths that link mediums, female chorus members, trance-dancers, and patients with spirits of the jungle and settlement' (Roseman 1993: 9). Altered states of consciousness have a widespread salience in the ritual practices of communities across Southeast Asia, and have been reported in various hill tribes (e.g. Rawson 1967: 140; Rashid and Walker 1975: 161; Chindorsi 1983: 187), and other groups including the Temiar people (Roseman 1993: 6), Chewong (Howell 1999: 64), and Aboriginal Malay communities (Laderman 1993: 13).

Concluding comments

The key distinction between the inland and peninsula sites appears to be the implication of the importance of the collective and the individual respectively, although a sense of unity through rock art production seems to permeate the corpus as a whole. A central theme in the inland sites discussed is the presence of 'scenes': depictions of something – be it literal, metaphorical, or desired – involving numerous members of the community, but seemingly produced by one individual artist. This differs from the peninsula sites, where it is proposed that individuals each contributed to a collective whole that was at once personal

Figure 10. Superimpositioning at Tham Lai Taeng. Photograph: L. Winch.

and shared. This may echo the relatively egalitarian and complementary nature of social organization seen in modern-day mixed strategy hunter-gatherer/ horticulturalist communities in the Malay Peninsula (e.g. Howell 1989: 45; Roseman 1993: 2-4). Among the Chewong, day-to-day tasks such as hunting, gathering, tending crops and production of shelters are centered on small family units (Howell 1999: 20), for example. It would therefore appear that the natural environment of the southern peninsula and the resources it provides may have dictated relatively small core groups, and whilst these groups may have been part of a larger whole, they were fundamentally self-reliant. This would be especially true in the coastal and mangrove environments, where the coastal rock art sites were clustered, with habitats unsuitable for rice cultivation or herding of domestic livestock. If the same were true in prehistory – bearing in mind that the peninsula is argued to be the most natural remaining part of the country (Higham and Thosarat 1998: 20) – the rock art here could therefore have served to at once unite members of the larger community in a shared tradition, whilst simultaneously demonstrating a representation of self, metaphorically manifested through the varied representations of humans and animals.

The inland environment, however, would have been more suitable for the adoption of various agrarian practices, whilst also offering continued opportunities for hunting and gathering. Activities such as land clearance and tending, and the rearing of livestock, would likely have been more efficient with the help of more hands, and therefore the adoption of incoming 'Neolithic' practices may have facilitated and promoted the growth of larger communities and potentially more of a communal ethos (cf. Shoocongdej 2002: 189; Higham *et al.* 2011: 530). Similarly, hunting of large land mammals such as deer, elephants, wild cattle and buffalo may also have benefitted from cooperative practices, whereas the animals that dominate the prehistoric archaeological deposits from the peninsula, such as fish, shellfish, turtles and monkeys (e.g. Shoocongdej 2000: 25-26; Anderson 2005: 141) could all have been obtained by lone hunters. As a result, I propose that the stronger sense of scene in the inland sites is related to the increased interdependence of people within the larger community, and their shared goals with respect to hunting and agricultural success. This sentiment is echoed in Shoocongdej's (2002) analysis of three inland rock art sites, where she observes that rituals among agrarian and mixed subsistence societies involve larger community groups than those of hunter-gatherers, and that 'ceremonialism serves to define local groups and to maintain regional intergroup relations' (*ibid.*: 189).

In conclusion, I argue that the core themes running through the peninsula rock art sites are the desire for safe and successful seaward forays, and a strong sense of identity in both shared and singular contexts. With respect to the inland sites, the sense of unity is more direct, as reflected in communal scenes including hunting and dancing. In both, a sense of the supernatural and shamanistic interaction therewith is also likely to have had an influence on the art. Perhaps, therefore, a more pertinent title for the analysis of faunal significance in this rock art corpus would be: 'Metabolism, mythology, magic AND metaphor'.

Tooth blackening and betel nut chewing at the Early Iron Age sites of Gò Ô Chùa (Vietnam) and Prohear (Cambodia)

Simone Krais, Michael Francken and Andreas Reinecke

Human teeth play a significant role in the reconstruction of biological life parameters. Dental modifications supply additional valuable insights into past human cultural behavior. At the Early Iron Age sites of Gò Ô Chùa (400-100 BC) and Prohear (main mortuary period 200 BC-AD 100), various patterns of intravitam dental staining have been found. Systematic visual analysis is presented here as a method for the thorough documentation and subsequent differentiation of specific staining patterns. Using evidence from ethnographical, historical and archaeological studies, the main pattern seen is interpreted as intentional tooth blackening. Since tooth blackening affects almost all adult individuals from Gò Ô Chùa, the custom was of high social relevance. Additionally, one individual shows staining interpreted as the unintentional result of betel nut chewing.

Introduction

Throughout history, humans have deliberately modified their bodies. In addition to medical and functional reasons, deliberate body modifications are used as expressions of individual and cultural identity. Humans use their bodies as symbolic social platforms, setting visual signs for others. Body modifications are related to ritual motives, social affiliations or significant life-cycle-events (Featherstone 2000; Kasten 2006; Favazza 2011). Most body modifications affect the soft tissues. For prehistory, normally only the bones and teeth can serve as evidence. Besides the intentional deformation of cranial bones (e.g. Gerszten and Gerszten 1995; Hoshower *et al.* 1995; Blom 2005; Ayer *et al.* 2010; Romero-Vargas *et al.* 2010), dental modifications are documented (e.g. Milner and Larsen 1991; Mower 1999; Vukovic *et al.* 2009; Barnes 2010; Domett *et al.* 2011). By a thorough documentation of body modifications, and comparison between neighboring archaeological sites, distinct regional modification patterns and differing practices can be reconstructed. This allows insights into common cultural grounds and cultural borders, as well as temporal and regional shifts of unique cultural behaviors (Blom 2005; Domett *et al.* 2011).

As biological artifacts, human teeth carry indications of age at death, health, nutrition and place of residence (e.g. Scott and Turner 1988; Kelley and Larsen 1991; Hillson 1996; Alt *et al.* 1998; Katzenberg 2008). Teeth are more durable than bones and have better chances of preservation in archaeological contexts. Various deliberate dental modifications, including ablation (the deliberate ante-mortem removal of teeth), dyeing, filing, incision or decoration of teeth with inlays of exotic material have been reported from archaeological sites around the world (e.g. Romero 1958; Mower 1999; Hudson 2004; Vukovic *et al.* 2009; Domett *et al.* 2011). Intentional dental modifications usually affect the anterior teeth, which are visible to other individuals, highlighting their social function (Mower 1999; Barnes 2010: 8). Unintentional dental modifications can, for example, result as a side effect from paramasticatory (tool-like) use of teeth for manipulative purposes (e.g. Larsen 1985, 1997: 258-262; Scott and Turner 1988: 109-112; Molnar 2011). Thus, modified teeth can serve as significant cultural artifacts. Moreover, compared to burial goods, teeth have better chances of being clearly associated with an individual when found *in situ*.

From prehistoric archeological sites in Asia intentional dental ablation (e.g. Kangxin Han and Nakahashi 1996; Tayles 1996; Vương Thu Hồng 2008; Francken *et al.* 2010; Domett *et al.* 2011), the intentional

blackening of the frontal aspect of teeth (Oxenham *et al.* 2002a), filing of teeth (Domett *et al.* 2011), and the decoration of teeth with gold inlays (Hudson 2004: 136-138) are documented. A further example of tooth alteration from Indonesia is discussed by Noerwidi *et al.* (this volume). To date, little attention has been paid to prehistoric intravitam dental staining. This might be due to possible misinterpretations of intentional, unintentional and taphonomic discoloration, the assumption that evidence of intentional staining is unlikely to be preserved, or difficulties in interpretation due to the variety of staining patterns and their various potential causes. Unintentional dental staining can result as a side effect from the consumption of food or oral use of substances, including dyeing agents (Larsen 1985, 1997: 258-262). Postmortem discoloration frequently occurs in archaeological teeth as a result of taphonomic and biochemical soil processes (e.g. Dye *et al.* 1995; Mansilla *et al.* 2003).

During anthropological examination of the human remains from the early Iron Age sites of Gò Ô Chùa (southern Vietnam) and Prohear (southeastern Cambodia) different patterns of intravitam dental staining were found on most human teeth, as well as one case of intentional dental ablation (Francken *et al.* 2010; Krais and Francken 2011; Krais *et al.* 2012). Systematic visual analysis and discussion of comparable archaeological finds and ethnographical studies are presented here for the interpretation of dental staining. Anthropological age classification in this paper follows German standards: the term subadult includes neonates (0-1 year), infants (2-12 years) and juveniles (13-19 years), and the term adult includes young adults (20-39 years), middle adults (40-59 years) and old adults (60 + years).

Materials

The site of Gò Ô Chùa is situated in Long An Province, southern Vietnam, close to the present-day Vietnamese-Cambodian border (Figure 1). Five excavation campaigns in 1997, 2003-2006 and 2008 uncovered the remains of sixty-eight inhumations and seven jar burials in three contiguous mounds, providing one of the largest prehistoric human skeletal collections on the Vietnamese side of the Mekong

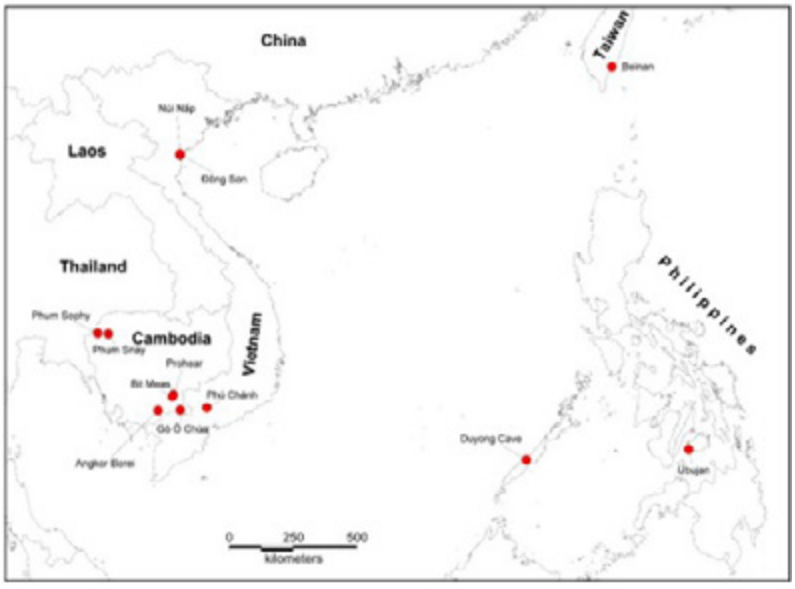


Figure 1. Archaeological sites mentioned in the text. Map by A. Reinecke.

Delta (Francken *et al.* 2010; Francken 2012). Calibrated radiocarbon dates and typical Iron Age ceramics suggest that the inhumations belong to the early Iron Age, dating from 400-100 BC (Reinecke *et al.* 2009: 39-44, 140-144). The human remains ranged from almost complete skeletons to single fragments. Most burials followed a common pattern of single bodies interred in a burial pit. Despite the fact that some burials overlapped, and all interments were densely packed, the majority of the graves seemed undisturbed and in a good condition. The jar burials were filled with human remains and contained neonates (0-1 year of age). A radiocarbon date from jar burial 5 of 2535 ± 45 BP (810-510 cal. BC; Erl-9406) suggests that they are older than the other sixty-eight inhumations, probably dating to the end of the Bronze Age or the beginning of the Iron Age (sixth to fourth century BC) (Francken 2012).

The inhumations were equipped with pottery and often with tools or weapons of iron or antler. Bronze objects such as bracelets and ornaments of precious stone or glass were rarely found. Exotic raw materials including turtle shell, predator teeth and ivory were also discovered. Small pots with the remains of animal bones were found in some of the graves, interpreted as food deposition. Due to burial equipment, which suggested migration, analysis of stable strontium isotopes was conducted on thirty-four individuals, and seven migrants were detected. By burial custom and ceramics, the cemetery of Gò Ô Chùa belongs to the Pre-Funan culture, which is distributed from southern Vietnam to at least northwestern Cambodia (Reinecke *et al.* 2009).

Located in southeastern Cambodia, the nearly completely looted site of Prohear (Figure 1) was excavated in 2008-2009 and 2011 by the German Archaeological Institute and the Memot Centre for Archaeology of the Ministry of Culture and Fine Arts in Phnom Penh (Reinecke *et al.* 2009, 2012). From seventy-six burials directly under the main road of the village, the remains of sixty-nine inhumations were recovered, along with seven jar burials. Many burials were partly looted or heavily destroyed, thus the skeletal remains of only forty-two individuals could be documented. Most burials had a southern or slightly southwestern orientation, and many were richly equipped with 'prestige' grave goods including glass, precious stone, gold and silver ornaments. Prohear shows the same general cultural characteristics of Pre-Funan culture as Gò Ô Chùa. However, the main mortuary period at Prohear was later, dating to 200 BC-AD 100. This is supported by radiocarbon dates as well as by the rich offering collections (Schlosser *et al.* 2012), including bronze drums or vessels, gold/silver ornaments, and orange-ware ceramics (Reinecke *et al.* 2012).

Acidic soil conditions in Prohear resulted in much poorer skeletal preservation compared to Gò Ô Chùa, and on average only about 10% of the bones of each individual were preserved. Teeth were preserved from twenty-nine individuals (n=313), including only twelve individuals represented by ten or more teeth (Krais and Seng Sonetra 2010, 2011; Krais *et al.* 2012). Thirteen out of forty-two individuals with examinable human remains (31%) were subadults of less than twenty years of age, while eleven (26.6%) were adults at the time of death, predominately young adults. For the remaining individuals, only rough age estimations ranging between subadult and adult were possible. Additionally, sex estimation based on features of the bones was possible only in one case (Krais *et al.* 2012).

To systematically map the dental modifications of both sites, only individuals with at least one evaluable tooth per jaw quadrant were included in this study. Heavily abraded teeth and teeth with severe pathological or taphonomic damage were excluded. Thus, for Gò Ô Chùa a subsample of twenty-four individuals from all three mounds excavated between 2003-2008, with a total of 534 teeth (68.3% of all available teeth), was assessed (Table 1). Regarding archaeological and anthropological data this subsample mostly resembles the inhumation burials of the entire cemetery (Francken 2012). The age composition of the subsample consists of five subadult individuals (two infants and two juveniles; 20.8%) and nineteen adult individuals (79.2%). The sex distribution within the subsample is almost balanced, with eleven individuals determined as males and nine

Table 1. Frequencies of all available, stained and unstained teeth of the Gò Ô Chùa sample in accordance to tooth classes (n=534).

Tooth class	No. teeth	Frequency of availability	No. stained teeth	Frequency stained teeth	Frequency labial/buccal staining	Frequency occlusal staining	Frequency lingual staining
I_1	63	11.8	53	84.1	82.5	15.9	17.5
I_2	63	11.8	52	84.1	82.5	11.1	11.1
C	68	12.7	56	82.4	82.4	17.6	13.2
P_1	77	14.4	56	72.7	71.4	19.5	13.0
P_2	73	13.7	46	63.0	60.3	20.5	12.3
M_1	75	14.0	24	32.0	24.0	20.0	10.7
M_2	69	12.9	13	18.8	14.5	13.0	7.2
M_3	46	8.6	8	17.4	10.9	10.9	4.3

as females. Results of an analysis of stable strontium isotopes made on the majority of the twenty-four individuals indicate a local signal for most of the skeletal remains (54.2%). Only 16.7% of the subsample displayed a non-local signal. Concerning burial goods, no obvious differences to the total of inhumations occurred in the sample.

Due to the poor preservation of the human remains of Prohear, only four adult individuals with a total of ninety-five teeth could be included in the study (burials 12, 15, 19 and 33). Since the sample is so small, only qualitative results are possible. Concerning burial orientation, three of the individuals were buried oriented to the south or slightly southwest and one oriented to the east (Krais *et al.* 2012). These four burials represent all three different mortuary periods at Prohear in a chronological framework from about 200 BC to 100 AD, and three of them are particularly richly equipped. Burial 19 belongs to mortuary period I (before the last quarter of the second century BC). In burial 15, from mortuary period IIa, twenty green earrings were discovered on both sides of the skull. Finally, burial 12, most likely belonging to the IIa/IIb transition period, and burial 33 of mortuary period IIb provided two of the richest finds of gold-silver jewelry at Prohear. In addition, the face of the woman in burial 33 was covered with a bronze bowl of south Chinese origin (Reinecke *et al.* 2009: 39-44).

Methods

For each individual the occlusal, labial/buccal and lingual/palatinal enamel surfaces of all teeth were systematically examined for the presence or absence of intravitam dental staining. A database was established in which the presence and appearance of all three aspects of every tooth were scored as follows: 1=entire tooth not preserved, 2=respective aspect not preserved, 3=aspect stained, 4=aspect not stained. Additionally, drawings were made of those aspects of the teeth with the specific location of staining. In completely preserved dentitions, not all interdental spaces are completely visible. Thus, the condition of interdental spaces was not documented for each tooth but for each individual. For each individual the shade and intensity of staining color was documented by photographs.

In a qualitative approach, for each site the individuals were grouped according to recurrent patterns, color shades and intensity of staining. For the largest of these groups, further statistical analyses regarding the locations and frequencies of each specific staining pattern are presented. Correlations with other archaeological and anthropological information (grave orientation, burial goods, sex, age at death, strontium isotope data) were investigated.

Results

For the site of Gò Ô Chùa, the frequency of availability of the total 534 assessed teeth, irrespective of staining and dying pattern, varied from 8.6% for the third molar to 14.4% for the first premolar (Table 1). All tooth classes have similar availability frequencies with the exception of the third molar, due to inclusion of subadult individuals. In total, 523 occlusal surfaces (97.9%), 515 labial aspects (96.4%) and 511 lingual aspects (95.7%) were scored. Independent of the localization of staining, 308 teeth (57.7%) show staining in at least one of the defined aspects. Only two of the twenty-four individuals included in the sample of Gò Ô Chùa – an infant not older than seven years (05GOC H3 F10) and an adult male of twenty-five to forty-five years (05GOC H4 F5b) which do not share any other particular features – showed no dental modifications at all.

The frequency of availability of the 95 teeth from the subsample from Prohear, irrespective of staining and dying pattern, varied from 10.5% for the canine to 14.7% for the first incisor. In total, forty-seven occlusal (49.5%), ninety labial (94.7%) and eighty lingual aspects (84.2%) were scored. Of this subsample, fifty-four teeth (55.1%) were stained on at least one aspect. In this sample, one of the four assessed individuals (burial 15) showed no dental staining.

All stained teeth included in this study display a white line on their cervical margins. During life, the tooth´s marginal aspect is covered by the gingiva. Thus, this line indicates that the staining was applied intravitam or perimortem. In many cases the stained teeth additionally show signs of wear damaging the staining. This indicates that the teeth were still in use after the staining occurred. As a consequence, the staining emerged antemortem and not in the context of postmortem rites.

Figure 2. Frequency of stained teeth of the sixteen upper and thirteen lower jaws with labial/buccal staining, in accordance to tooth classes (n=386). Plot by the authors.

Figure 3. Gradual anterior-posterior decline of intense reddish-brown staining. Photo: S. Krais.

However, on an individual level the stainings encountered in both sites followed four different patterns: intense reddish-brown staining on labial and buccal aspect on the upper and lower jaw, intense reddish-brown staining on labial and buccal aspect only on the upper jaw, intense reddish-brown staining on all aspects, and irregular light yellowish dyeing on varying aspects (Table 2).

Intense reddish-brown labial and buccal staining

In the sample from Gò Ô Chùa, sixteen individuals (66.7%; six females, one probable female, seven males and two probable males, with a total of 155 female and 231 male teeth), show intense staining on the labial and buccal aspects (Tables 2 and 3), with very intense staining on the frontal teeth, decreasing dyeing intensity towards the premolars, and almost complete absence towards the molars (Figures 2 and 3). Besides a very slight variation concerning the beginning of the decrease of density – which varied from mostly the second premolar or the first molar to a few cases of the first premolar – the pattern is similar among all the assessed individuals. Interdental spaces in this group are not stained. Except for one individual with a possible age at death of seventeen to twenty-two years, only adults (young, middle and old adults) are included. This group includes local and non-local individuals, and no association with specific grave orientation or specific burial goods was found.

Table 2. Overview of individuals and dental staining patterns in the subsample of Gò Ô Chùa and Prohear.

Gò Ô Chùa	**Burial**	**Comments on staining/ modification**	**Age at death**	**Sex**	**$^{87}Sr/^{86}Sr$**	**Orientation**
No dyeing	05GOC H3 F10		~5-7	-	local	SE
	05GOC H4 F5b		25-45	M	-	ESE
Tooth blackening - upper and lower jaw (intense reddish-brown staining on labial/ buccal aspect)	05GOC H1 L3 F22		25-30	F	local	ESE
	05GOC H1 L3 F23		50-70	F	local	ESE
	05GOC H5 L3 F14		17-22	M	local	ESE
	05GOC H5 L4 F27		19-22	F	non-local	SSE
	05GOC H5 L4 F31	ablation upper jaw	20-30	M	non-local	ESE
	05GOC H5 L6 F35		25-46	F	local	SSE
	05GOC H6 L3 F24		33-42	M	non-local	SSE
	06GOC H2 F38		20-25	M?	local	NW
	06GOC TS1 F3		47-64	M	local	SE
	08GOC H1 L4 M5		40-59	F	-	SE
	08GOC H1 L5 M1		20-25	F	-	SE
	08GOC HI M4		30-49	M	-	SE
	05GOC H5 L2 F7a	Additional occlusal staining	25-33	F?	local	SE
Tooth blackening – only upper jaw (intense reddish-brown staining on labial/buccal aspect)	05GOC H6 L6 F36	Additional occlusal staining	20-40	M	local	SSE
	08GOC H1 L6 M2		30-49	M	-	SE
	06GOC TS1 F4	Additional occlusal staining	24-30	M?	local	SE
Betel nut chewing	08GOC HI M6	All aspects stained	~15	-	-	SE
Irregular light yellowish dyeing	05GOC H2 L2 F3	All aspects stained	~18	-	local	SSE
	05GOC H6 L2 F17	Labial/buccal aspect of upper and lower jaw stained	20-30	F?	local	SE
	05GOC H4 L5 F34	Labial/buccal aspect of upper and lower jaw stained	18-22	F?	non-local	SSE
	05GOC H9 L4 F13b1	Labial/buccal aspect of upper and lower jaw stained, stained calculus?	24-47	M	-	SSE
	06GOC TS1 F6	All aspects stained, additional stained tooth	5-9	-	local	SE
Prohear						
No dyeing	Burial 15		20-29	-	non-local	SSW
Tooth blackening – upper and lower jaw (intense reddish-brown staining on labial/ buccal aspect	Burial 19		20-39	-	rather local	E
	Burial 33		40-49	-	non-local	SSW
Irregular light yellowish dyeing	Burial 12	All aspects stained	20-39		non-local	SSW

Figure 4. Individual with labial and buccal staining on the upper and lower jaw. Photo: S. Krais.

Figure 5. Labial and buccal staining on the upper jaw. Photo: S. Krais.

Figure 6. Dental staining of occlusal enamel surfaces. Photo: S. Krais.

Figure 7. Overall staining of all aspects. Photo: S. Krais

Of this group, thirteen individuals (five males, one possible male, six females and one possible female) have this staining pattern on the teeth of the upper and lower jaws. But three adult individuals (two males, one possible male; young to middle adult individuals) show this characteristic pattern only on the teeth of the upper jaw, while the teeth of the lower jaw are not stained (Figures 4 and 5; Tables 2 and 3). Two of these have local isotope values, while for the third no isotope data are available. The orientation of the three burials was south-southeast and southeast, the most frequent orientation in the site. Again, no association with specific grave orientation or specific burial goods was found. Additionally, three individuals (two with staining only on the upper jaw, one with staining on the upper and lower jaw) also have traces of less intense staining on the occlusal aspect on thirty-two of fifty-nine (54.2%) of their teeth (Figure 6; Table 2). With the exception of one first molar, all of the occlusal stained teeth (1/31) belong to males (Table 3).

In the site of Prohear, two of the four assessed individuals (burials 19 and 33) show the pattern of intense reddish-brown labial and buccal backwards declining staining (Table 2). The individuals do not share any other particular features regarding other anthropological or archaeological parameters.

Overall reddish-brown staining

One individual of the Gò Ô Chùa sample (08GOC HI M6; twenty-three stained teeth) showed an exceptional staining pattern with slightly irregular moderate reddish-brown staining on the labial/buccal, lingual and occlusal surfaces (Figure 7; Table 1). Interdental spaces and abraded occlusal spots were also stained. The grave position and burial goods of this individual did not show any particularly notable features, but unusual pathological characteristics are present. In addition to very high caries intensity (mild to very strong caries lesions in sixteen of the twenty-four evaluable teeth) and traces of unspecific periosteal reaction on several bones (the epiphysis caput humeri, the processus articularis superior, the sacrum and parts of the pars petrosa), the proportions of the cranial and the postcranial skeleton appear very small compared to the cranium. Additionally, parts of the frontal, sagittal and lambdoid suturae are already in fusion, although tooth status, tooth cementum analysis (Wittwer-Backofen *et al.* 2004) and epiphyseal fusion suggest an age of about fifteen years old. This indicates premature suture closure (craniosynostosis), a pathological condition which can be very painful.

Table 3. Staining pattern of Gò Ô Chùa subsample, distributed by tooth class for female and male individuals, based on individuals of group 2 'tooth blackening – upper and lower jaw' and group 3 'tooth blackening – only upper jaw' from Table 2 (n=386).

Surface	Sex	Attribute	Tooth Class							
			I1	**I2**	**C**	**P1**	**P2**	**M1**	**M2**	**M3**
Labial/buccal	Female	Stained	15	18	19	21	13	3	0	0
		Unstained	0	0	0	0	9	19	19	12
	Male	Stained	23	22	22	22	19	3	1	1
		Unstained	3	4	4	8	12	28	29	20
	p-value		0.287	0.133	0.126	0.015	1	0.683	1	1
Occlusal	Female	Stained	0	0	0	0	0	1	0	0
		Unstained	15	18	19	22	23	22	20	13
	Male	Stained	2	2	3	5	6	6	4	3
		Unstained	25	25	24	27	24	27	28	18
	p-value		0.530	0.510	0.257	0.072	0.030	0.071	0.151	0.270
Lingual/palatinal	Female	Stained	0	0	0	0	0	0	0	0
		Unstained	15	18	19	21	23	23	20	14
	Male	Stained	0	0	0	0	0	0	0	0
		Unstained	25	25	25	29	29	30	30	20
	p-value		1	1	1	1	1	1	1	1

Figure 8. Overall staining of all aspects. Photo: S. Krais.

Figure 9. Infant with staining on tooth buds. Photo: S. Krais.

Slight yellowish staining

Five individuals from Gò Ô Chùa (20.8%) and one individual from Prohear show very light brownish to yellowish staining (Figure 8; Table 2). Within this group there seems to be little accordance between the patterns besides the low intensity itself. Three individuals show the staining on all aspects of the teeth almost evenly, while three show the staining only on the labial/buccal aspects. Surprisingly, one individual from Gò Ô Chùa (06GOC TS1 F6) additionally has seven stained unerupted teeth (Figure 9).

Ablation

Beside the labial and buccal staining of the upper and lower jaws, one individual from Gò Ô Chùa (burial 36, H5 DT 31), a twenty to thirty year-old non-local male, showed an additional dental modification. Both upper lateral incisors (Francken *et al*. 2010) were absent (Figure 10; Table 2). The remaining interdental space between the first incisors and the canines excluded a congenital tooth absence (anodontia) as an explanation (Tayles 1996: 335), and the absence of pathological conditions like inflammation and bone remodeling on the maxilla, or carious lesions and damage on the adjacent teeth, reduce the possibility of natural causes for the loss of the teeth. Thus, an interpretation as intentional ablation is very likely.

Figure 10. Dental ablation additional to labial and buccal staining on the upper and lower jaw. Photo: S. Krais.

Discussion

In the following discussion, the introduced staining patterns are interpreted as intentional and unintentional dental modifications, based on visual analogies and social practices that still exist today. Archaeological and historical evidence is used to discuss the antiquity and continuity of the habits, while ethnographic information helps us to speculate on potential motivations and social parameters.

Tooth blackening

The sites of Gò Ô Chùa and Prohear contain large proportions of individuals with intense reddish-brown staining on the labial/buccal aspects of their frontal teeth (Gò Ô Chùa: 17/24 individuals; Prohear: 2/4 individuals). This staining pattern is interpreted as tooth blackening, a habit still practiced in parts of South America, Asia, Melanesia and Micronesia. Archaeological, historical and linguistic evidence show that tooth blackening is an ancient custom (Bailit 1968; Flynn 1977; Tayanin and Bratthall 2006; Zumbroich 2009, 2011: 97; Barnes 2010: 17). Nevertheless, particularly due to the 'Western ideal of white teeth', today tooth blackening is losing its importance (Zumbroich 2009: 382).

In Gò Ô Chùa, the high occurrence of tooth blackening speaks to a strong social relevance. In general, the fact that the staining is applied to the front teeth, which are visible to others, highlights the custom's social function. The stained individuals from Gò Ô Chùa and Prohear show a decline of dyeing intensity towards the premolars, and almost complete absence at the molars; interdental spaces were not stained. Ethnographic evidence shows that materials and techniques of tooth blackening vary among different centuries and populations (Flynn 1977: 97; Smith 2003; Tayanin and Bratthall 2006: 84-85; Zumbroich 2009). Mostly soot or pastes from botanical ingredients are applied to the frontal teeth, producing the described staining pattern. The Kammu people, for example, produce a viscous soot by burning the woods of *Cratoxylum formosum*, *Croton cascarilloides* and/or *Dracontomelon dao*, and apply the soot with the index finger to the anterior aspect of the teeth, producing a dark staining declining towards the molars (Tayanin and Bratthall 2006: 83). The staining pattern from our samples indicates a similar procedure.

The age distribution in our samples from Gò Ô Chùa and Prohear indicates social rules concerning application time, since the estimated age-span of the youngest affected individual starts at seventeen years. On the other hand, males and females wear the staining, indicating that no gender-based restrictions existed. In contemporary groups, teeth are frequently blackened around puberty. For

example, the Kwaio from the Solomon Islands 'blacken their teeth around the age of 14-16' (Zumbroich 2009: 381; see also Bailit 1968: 350). Social restrictions regarding sex vary notably among different cultural groups (Bailit 1968; Flynn 1977; Smith 2003; Tayanin and Bratthall 2006; Zumbroich 2009, 2011). Amongst the Kammu (Vietnamese: Khơ-mú) in Laos and Vietnam, for example, only women dye their teeth (Tayanin and Bratthall 2006: 81), while amongst the Mengen of south-central New Britain tooth blackening was obligatory for unmarried men (Zumbroich 2011: 107).

Three interesting aspects concerning our prehistoric samples have not been addressed in the current literature. First, the prevalence of staining only on the upper jaw is not documented in any other report and is unique for Gò Ô Chùa. All three affected skeletons are probably male, of young to middle adult age, their burials oriented to southeast or south-southeast, and the two available isotope values indicate a local origin. Secondly, the generally high intensity of the staining in Gò Ô Chùa and Prohear varied very slightly between individuals. Taphonomic processes might serve as an explanation for this phenomenon. The individually varying timespans between the application of the tooth-blackening substance and time of death could be another possible explanation. Third, the additional occlusal staining of some individuals from Gò Ô Chùa is absent in the current literature. It indicates an application of the stain close to the time of death; otherwise it would have been eradicated by dental abrasion due to food intake.

While it is unknown why these prehistoric people performed tooth blackening, it is interesting to investigate ethnographic information. In modern groups, general motivations range from attractiveness and cosmetic reasons, to the covering of the canine teeth and the differentiation of humans from animals and demons, or its use for tooth preservation as protection against acids, such as those produced by betel-nut chewing (Bailit 1968: 348; Reid 1988: 75; Tayanin and Bratthall 2006: 85; Zumbroich 2009: 391). In some Melanesian groups tooth blackening is incorporated into ceremonies and 'magical procedures', while in some Oceanic groups it is 'part of the elaborate ritual cycles celebrating different life stages' (Zumbroich 2009: 381, 2011: 107). Also, inverse relationships of tooth blackening and dental pathologies like caries and gingival inflammation have been reported, and the integration in cultural systems due to medical reasons for prophylaxis and acute oral care or 'aftercare for teeth filing' has been discussed (Bailit 1968: 352; Tayanin and Bratthall 2006; Zumbroich 2011). Ethnobotanical analysis suggests that plants used for tooth blackening are considered to be of medical value traditionally and have a high content of 'bioactive constituents' (Zumbroich 2011: 97, 99). The soot used for tooth blackening by the Kammu people reduced growth of *mutans streptococci* in saliva (Tayanin and Bratthall 2006: 81).

In Southeast Asian archaeological contexts, tooth blackening is already documented for large proportions of skeletons of both sexes from the site of Núi Nấp, northern Vietnam (Oxenham *et al.* 2002a). This site is potentially from the same period as the burials from Prohear or Phú Chánh, based on burial offerings which appear to relate to the transition period from Đông Sơn to Han cultures during the last century BC and first centuries AD (after Hà Văn Phùng 1984; *ibid*.), and one radiocarbon date, although a second to sixth century AD date, which is given without explanation of the origin of the dated sample by Oxenham *et al.* (2002a: 910). For Núi Nấp, investigations of the staining pattern, enamel surface morphology and GC/MS analysis suggest intentional application of a substance including a tannin derivative, which might originate from *Areca catechu* (Oxenham *et al.* 2002a: 909). From the Alaguan site on Rota, Mariana Islands, deliberate staining on the front surfaces of mainly female teeth is reported for the Latte Phase (AD 1100-1700). By GC/MS-analysis of this staining, two tetrahydropyridine alkaloids characteristic of betel nut (*Areca catechu* L.) have been detected, suggesting that betel nut was used for intentional tooth blackening (Hocart and Frankhauser 1996: 281). Although today *Areca catechu* is not frequently used as a main ingredient for tooth blackening, its use is reported (Zumbroich 2008: 122).

Although the Đông Sơn culture site Núi Nấp in northern Vietnam, and the previously-mentioned sites of the Pre-Funan culture in southern Vietnam and southern Cambodia are far away from each other – about 1000 kilometers – they were connected by strong cultural contacts and migrations during the Iron Age. In this respect, we can identify influences going from north to south, e.g. by the distribution of bronze drums of Đông Sơn type at Prohear, Phú Chánh or Bit Meas, much better than in the opposite direction. Although the number of large-scale investigated Iron Age burial sites with well-preserved and analyzed human remains is still too small to make large-scale interpretations based on tooth staining patterns, the shared tooth blackening also links the sites.

Betel nut chewing

Only one skeleton from our sample, individual M6 from Gò Ô Chùa, showed the remarkable overall reddish-brown staining on all teeth. The staining pattern is interpreted as the unintentional result of betel nut chewing. In betel nut chewing, the seed of the areca nut (*Areca catechu* L., Arecaceae) is chewed in combination with betel leaf (*Piper betel* L., Piperaceae) and lime paste (calcium hydroxide). The mixture of these ingredients creates brownish-reddish salvia which reaches all aspects of the teeth (even interdental spaces). Habitual use leads to the staining of all enamel surfaces, and depending on the degree of oral care, hygiene and the period of chewing, the color intensity varies from red to black (Rooney 1993: 28).

Today, the betel quid is one of the most commonly consumed psychoactive substances in the world. It is consumed for its mild stimulating and narcotic effects, but is also part of rituals and traditional medicine (Reid 1985: 531-535; Rooney 1993: 12; Zumbroich 2008: 118-119, 127). Anti-cariogenic but also carcinogenic effects are reported from medical contexts (Reichart *et al.* 1985: 466). Today its geographical distribution is centered in South and Southeast Asia and extends from Madagascar to the Solomon Islands.

Zumbroich (2008) published an excellent overview on the origin and diffusion of betel nut chewing in South Asia. Historical, linguistic and ethnographic sources speak for its existence in Southeast Asia for more than two thousand years (Reid 1985: 529-530; Rooney 1993: 12; Zumbroich 2008). Archaeological evidence for betel nut chewing reaches back to the Neolithic period, but it is not always unmistakably definitive – associated artifacts, botanical remains, and stained teeth are rather indirect evidence. For example, *Arca* shells found in a number of Neolithic complexes in caves on Palawan in the Philippines have been interpreted as lime containers, since one of them was filled with lime (Fox 1970: 62-63). However, calcium carbonate deposits form naturally in these limestone caves, there are also deposits of wood ash and altered bone in cultural layers, meaning that this is not a clear-cut connection. In two burial pits at the Phú Chánh site, southern Vietnam, Areca fruits have been found together with other offerings, including a late Western Han period mirror, dating the complexes to about 2000 BP (Bui Chi Hoang 2008). Nevertheless, the presence of the fruit cannot prove that it was used for betel nut chewing. Also, the association of the bronze 'thố'-vessels discovered in many burials of the Đông Sơn culture (Hà Văn Tấn 1994: 101-105) with betel nut chewing is not fully proven (Janse 1958: 56-58).

Characteristic dental staining at Duyong Cave in the Philippines was interpreted as evidence that 'the areca nut palm (*Areca catechu* L.) and betel chewing was of prehistoric introduction, appearing possibly as early as the late phase of the Early Neolithic' (Fox 1970: 65). Similar interpretations of dental staining are reported from Neolithic and Metal Age sites including Ubujan, Bohol (Philippines), Beinan (Taiwan) (Zumbroich 2008: 99), from the Melanesian pre-Latte (AD 1-1000) and Latte (AD 1000-1521) periods (*ibid.*: 112; Bellwood 1979: 285; Pietrusewsky *et al.* 1997; Ikehara-Quebral and Douglas 1997) and from Vat Komnou cemetery at Angkor Borei in southeastern Cambodia (200 BC-AD 400) (Pietrusewsky and Ikehara-Quebral 2006: 89), a site closely related to Prohear. Unfortunately, detailed descriptions of the staining patterns are frequently absent or too vague for a useful differentiation from tooth blackening.

To validate the interpretation that the characteristic staining from individual M6 from Gò Ô Chùa is the result of betel nut chewing, biochemical analyses of the stained dental material were conducted (Krais *et al.* 2016). By liquid chromatography-tandem mass spectrometry (LC-MS/MS) and liquid chromatography-high-resolution mass spectrometry (LC-HR-ToF-MS) the alkaloid arecoline which is specific for *Areca catechu* L. (Arecaceae) was detected. This detection of specific betel nut alkaloids on dental material can be valued as direct evidence for prehistoric oral betel nut use. Regarding the various pathological lesions on the skeleton of the individual, it could be hypothesized that this person chewed betel nut to achieve a feeling of relief or well-being in context of healing or ritual purposes.

Differentiation of tooth blackening and betel nut chewing

Tooth blackening and betel nut chewing are distinct cultural behaviors with different motivations and social functions. Regarding geographical distribution today and in prehistory, overlaps are assumed. Since both customs result in reddish-brown staining, confusion in interpretation is possible. For the visual differentiation of both customs, thorough investigation of all three surfaces and interdental spaces regarding staining position, color shade and intensity is very useful. Additionally, biochemical evidence can validate the interpretation of betel nut chewing. However, special attention has to be paid to the fact that betel nut can also be used as a dyeing agent in tooth blackening. Hocart and Frankhauser (1996) investigated dental material of stained labial surfaces and found two tetrahydropyridine alkaloids specific for *Areca catechu* L. (arecaidine and guvacine). Zumbroich (2009: 381) points out the possibility of conflation between both customs, but Hocart and Frankhauser (1996) tested both the stained labial and the unstained buccal surfaces. The alkaloids were only present on the stained labial surfaces, proving that betel nut was used to effect the staining, and that the alkaloids did not derive from additional betel nut chewing.

Slight yellowish staining

Five individuals from Gò Ô Chùa and one individual from Prohear show patterns of very light yellowish dental staining. The inconsistency and irregularity within the group concerning color shades and position suggests various reasons, rather than a simple uniform explanation. In general, very light dental staining can be due to the consumption of foods and drinks or otherwise oral use (like smoking or chewing) of substances including dyeing agents. In our sample, three individuals show light staining on all aspects of the teeth, while three show it only on the labial/buccal aspect of upper and lower jaw. Since these positions resemble the previously discussed patterns of tooth blackening and betel nut chewing, it cannot be excluded that these are cases where the dyeing process occurred a long time before time of death of the individual. Additionally, the fact that one individual has stained unerupted teeth, which during their lifetime definitely were not exposed to any of these factors, serves as evidence for the influence of unknown taphonomic processes.

Ablation

One individual from Gò Ô Chùa (burial 36, H5 DT 31) shows dental ablation. The intentional ablation of teeth is a common cultural modification that has been found worldwide from prehistoric and modern times (e.g. Inoue *et al.* 1995; Kangxin Han and Nakahashi 1996). Several authors have reported dental ablation in skeletal samples from Thailand to Vietnam, ranging from Neolithic to Iron Age in date (Song Sangvichien 1966; Tayles 1996; Nelsen *et al.* 2001; Oxenham *et al.* 2002b; Domett *et al.* 2011). According to the analysis of Domett *et al.* (2011: 5) the ablation of the lateral incisors in the maxilla of the individual from Gò Ô Chùa resembles 'pattern 1' ablation, the most common pattern (72.9%) seen in the Cambodian sites of Phum Snay and Phum Sophy (*c.* 500 BC-AD 500) (*ibid.*). With only one individual presenting an ablation here, it is only possible to speculate about the cultural meaning within this context. The non-

local isotopic value of the skeleton speaks in favor of a migration background, and the offerings of seven small glass rings near the neck and seven iron arrowheads near the left shoulder suggest that the buried man may have been a hunter.

Conclusions

Using systematic dental analysis, intravital dental stainings have been documented in the samples from the early Iron Age sites of Prohear and Gò Ô Chùa. Based on current ethnographical, archaeological and historical research, the staining was interpreted as intentional tooth blackening (Gò Ô Chùa: 16/24, Prohear 2/4 individuals) and betel nut chewing (Gò Ô Chùa 1/24 individuals). The high frequency of tooth blackening indicates the social relevance of this custom at that time. The custom affected both sexes and was not performed before individuals became young adults. On a regional and temporal level this specific cultural behavior links the Iron Age sites of Gò Ô Chùa, Prohear and Núi Nấp. Beside tooth blackening, one case of betel nut chewing was detected in Gò Ô Chùa.

Body modifications like tooth blackening are specific cultural habits that are of high social relevance. The reconstruction of such rites by studying biological tissues enables insights into past cultural behavior. Thus, culturally modified teeth are not only a valuable biological, but also a unique cultural artifact and need more attention in archaeological research. For useful interpretations, analysis of dental staining has to include a thorough description of staining locations, color shades and intensities. Additionally, the example of tooth blackening and betel nut chewing shows the importance of thorough documentation for differentiation of the two customs. In site comparisons, like other archaeological artifacts, dental modifications can help to reconstruct common cultural grounds. Further studies should be done on dental modifications in other sites to broaden our knowledge of regional and temporal significance of the different types of dental staining. Ideally, besides visual analysis, biochemical analysis should be performed for validation of possible interpretations and the identification of dyeing agents.

Acknowledgements

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The cultural and biological context of the Song Keplek 5 specimen, East Java: implications for living conditions and human-environment interactions during the later Holocene

Sofwan Noerwidi, Harry Widianto and Truman Simanjuntak

The Song Keplek 5 (SK5) specimen was found in 1998 at the Song Keplek site in the Gunung Sewu (Southern Mountains) karst region, East Java, Indonesia. SK5 is a human burial, AMS-dated from its bone fragments to c. 3053 ± 65 cal. yr. BP (AA96775). This paper discusses the archaeological and biological context of SK5. Biological information includes sex determination, estimation of age, height and weight, and indicators of systemic pathology. Discussion of archaeological context includes cultural practices in evidence during this individual's life, and subsequent funerary practices post-mortem. This exploration of the cultural and biological context of SK5 begins to flesh out an 'osteobiography' for this individual, and improves our understanding of living conditions and human-environment interactions during the later Holocene in Java.

Introduction and background

The Indonesian archipelago occupies a very strategic position in the history of human evolution (e.g. Jacob 1967), and also in the modern human colonization of the Indo-Pacific region (e.g. Bellwood 1978). This research is focused on the issue of the migration of Austronesian-speaking ancestral peoples into the Indo-Pacific region during the middle and late Holocene, a migration for which several different models have been proposed. In this paper we focus on three of these. The first, based on archaeological, linguistic and genetic criteria (Blust 1984-1985; Bellwood 1989; Pawley and Ross 1995; Chambers 2006), suggests a migration of early Austronesian-speaking people from Taiwan. The second, based mainly on cranial analyses, archaeological data and to some extant genetics (Solheim 1984-1985; Oppenheimmer 1998; Pietrusewsky 1990, 2006), suggests an expansion from Island Southeast Asia. A third, based originally on lexicostatistical analysis and the Darwinian concept of an 'entangled bank', suggests an origin in the Melanesian region (Dyen 1965; Terrell 1986).

At present, the most widely-accepted explanation for the dispersal of Austronesian-speaking people is the Bellwood-Blust model derived from a combination of historical linguistic and archaeological data, which suggests movements of Austronesian-speaking ancestral people via Taiwan, and ultimately from the eastern coastal regions of southern China, possibly starting around 7000 BP (Bellwood 1995). This 'Out of Taiwan' theory proposes fairly rapid Austronesian expansion onwards from Taiwan, starting there from about 4000 BP and moving via the Philippines into the rest of Island Southeast Asia (Tanudirjo 2006: 87).

The 'Out of Taiwan' theory suggests that the Indonesian Archipelago was settled from the north by a linguistically related and expanding population of 'Southern Mongoloid' biological affinity, carrying Austronesian languages in the Malayo-Polynesian subgroup and Neolithic cultural items from 4000 BP onwards (Bellwood 1997). This theory has strong evidence in support (Tanudirjo 2006), but its application in many places is not crystal clear because of gaps in the data in different regions (Spriggs 2000). Also, when Austronesian people first arrived in the Indonesian archipelago, the region was not unpopulated. In several islands, and especially Java, there is evidence for the existence of communities at least since Paleolithic times (e.g. Détroit 2002).

The initial migration of anatomically modern humans into Indonesia occurred at an uncertain date, but there are claims for modern humans in tropical Asia to as far north as southern China since the Last

Interglacial (marine isotope stage 5), which commenced at *c.* 125,000 BP (Westaway *et al.* 2007). Stronger evidence appears after 60,000 BP, especially with the Niah Cave specimens (e.g. Harrisson 1957, 1959, 1965; Barker and Richards 2013), early charcoal dates from Tabon Cave (Fox 1970) and the settlement of Australia at least 40,000-50,000 BP (e.g. Hiscock 2008). Important evidence for an early modern human presence in Java at this time comes from Gunung Sewu in the Southern Mountains region (Storm *et al.* 2005; Sémah *et al.* 2006: 21). The Javanese record is dominated by cave habitation by pre-Neolithic populations to as recently as around 2000 BP (Widianto 2006: 182).

Java today is the most densely settled island in the Indonesian archipelago. From genetic and linguistic perspectives, the indigenous population of the island comprises a mainland Asian Mongoloid-affiliated people who speak Austronesian languages (Widianto 2006; Blust 2013). But reconstruction of the colonization processes of Java by the ancestors of its modern people remains difficult. From a linguistic perspective, Blust (1984-1985) has suggested the existence of a Java-Bali-Sasak subgroup, closely related to the Malayo-Chamic languages in western Indonesia and Vietnam, and to the Barito language in South Borneo (including Madagascar). He suggests that a common proto-language was spoken in southeast Kalimantan approximately 1500-1000 BC, and that the above languages were separating around 800-1000 BC (*ibid.*). However, archaeological evidence to test Blust's linguistic hypothesis has been rarely found in Java.

A number of open-air Neolithic habitation sites have been found in Indonesia, and several have been quite intensively researched, such as Uattamdi in the northern Moluccas (*c.* 3200 BP), Kamassi and Minanga Sipakko in West Sulawesi (*c.* 3500-2500 BP), Punung in central Java (*c.* 2100-1100 BP), and Kendeng Lembu in East Java (*c.* 1350 BP) (Simanjuntak 2002; Simanjuntak *et al.* 2008; Noerwidi 2009). Unfortunately, so far, the Neolithic horizon has produced limited paleoanthropological data for the human population that occupied the sites. There are a lot of specimens from pre-Neolithic and later Metal Age ('Paleometallic') sites distributed across Java (e.g. Widianto 2002). But there is a general gap in historical reconstruction between these periods, meaning that all Neolithic skeletons must still see comprehensive paleoanthropological study in order to understand how Neolithic 'Austronesian-speaking' people lived and died on this island. That study would also be significant for the ethnogenesis of the Javanese people, because it is very rare for a human skeleton with a good Neolithic context to be found in Java, making the Song Keplek specimen very important.

Thus far, study of the SK5 skeleton has shown it to have strong Southeast Asian (Mongoloid) affinity (Noerwidi 2012). In this paper, additional traits of this individual are discussed with the aim of beginning to develop a comprehensive study of the Neolithic people of Java, starting with a morphological study of the Song Keplek specimen, exploring biological aspects and the cultural context of the skeleton.

Methods

Paleoanthropology uses standard scientific techniques developed in physical anthropology to identify human remains and their culture (e.g. Henke and Tattersall 2015). Paleoanthropology tries to understand the forms and variations of the human skeleton in individuals and populations, with a basis in applied biological and cultural knowledge concerning the human skeleton. The examination process of human remains in paleoanthropology includes three stages (White and Folkens 2005), which are followed here. One of these is providing a biological profile including age, sex, stature, ancestry, anomalies and/or pathologies, and individual features of the remains. The second stage provides data regarding the death event, including evidence of the rituals which occurred just after death (perimortem period), such as funerary practices or burial customs. The last stage consists of understanding the taphonomical processes which occurred in the postmortem period, based on the conditions of the remains and their environmental context (*ibid*.).

Song Keplek

Song Keplek is an important site in the Gunung Sewu karstic region. The site is located at the bottom of a hill at 333 meters above actual sea level (Figure 1). In front of the cave there is a long and narrow slope flanked by two hills, which descends about 200 meters to the Pasang River in the southeast. Most of the back part of the cave is filled with huge boulders of limestone, which have fallen from the roof. In the front part, with a twenty meter-wide entrance, the main chamber is oriented northwest-southeast (Simanjuntak 2002).

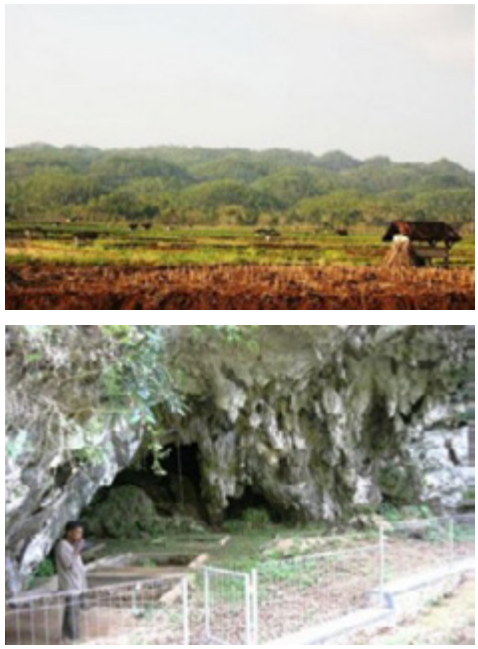

Figure 1. Gunung Sewu karst landscape (top), and the Song Keplek site (bottom). Photos by the authors.

In the Song Keplek site, twelve squares were excavated: six two-by-two meter squares and another six squares with various measurements. The deepest squares excavated were B6 and A5, which reached around six meters depth. The other squares were excavated to a shallower depth because of the presence of large limestone blocks. Vertically, the cultural sequences in Song Keplek can be divided into pre-Neolithic (or Mesolithic, in the older terminology) in layers 4 to 2, and Neolithic in layer 1 (Figure 2; Simanjuntak 2002).

The upper part of Song Keplek was composed of layers 1a, 1b and 1c, which contained fragments of pottery and polished stone adzes. These were dated between 700 and 3000 BP and correspond to the Neolithic period. Below the Neolithic phase are layers 2, 3 and 4, which were rich in flakes and bone tools, span from *c.* 4500-8000 BP, and correspond to the 'Keplek period' (Figure 3) (Simanjuntak 2002). Layer 5 is the deepest human occupation layer. It yielded flakes and faunal remains which suggest a correspondence with the so-called 'Tabuhan layer', locally known from Gua Tabuhan and Song Terus sites. The dates for the Tabuhan period extend between 15,880-24,420 yr. BP (Figure 3) (*ibid.*).

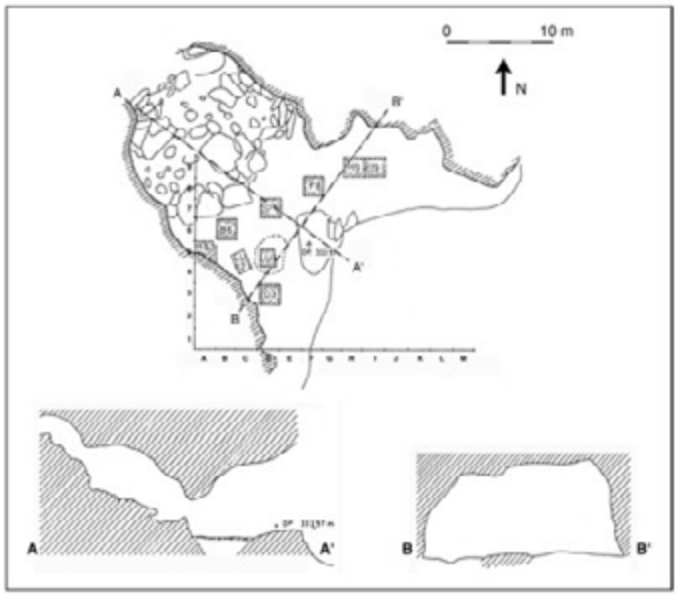

Figure 2. Plan of Song Keplek, after Simanjuntak 2002; Détroit 2002 (with permission).

The human remains found in Song Keplek during the first excavation in 1992 belong to three individuals. Two additional specimens were found during subsequent excavations. The three first individuals – SK1, SK2 and SK3 – are documented only by cranio-dental fragments. These three sets of human

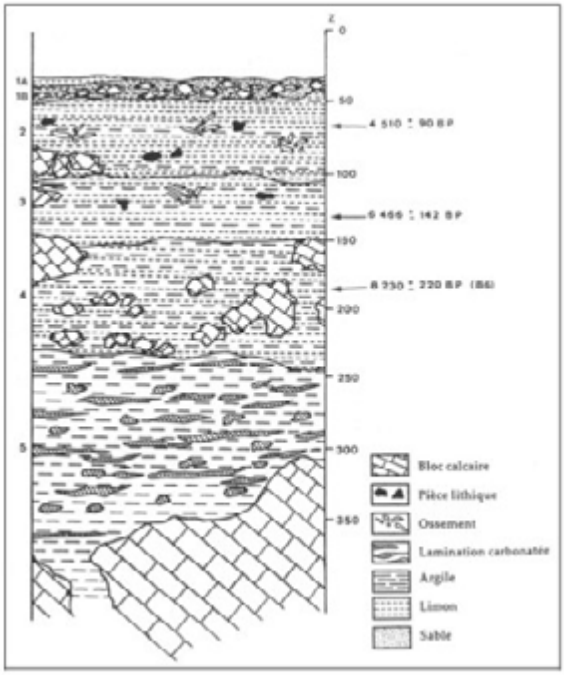

Figure 3. Stratigraphy of Song Keplek, after Simanjuntak 2002; Détroit 2002 (with permission).

remains were found in squares D3 and B6, in level 2, which corresponds to the youngest part of the Keplek cultural period (Simanjuntak 2002). The two skeletons found in the following years, named SK4 and SK5, were fortunately in better condition than the first three, and represent almost complete skeletons. All of these specimens, including SK5, have been analyzed morphologically by Widianto (2002), and in terms of morphology and upper face morphometrics by Détroit (2002).

SK5, the main object of this study, was found in square H9-I9, in the context of a straight primary burial (Figure 4). A radiocarbon date obtained on a charcoal sample from the sediments around SK5 gave an age of 7020 ± 180 BP (Simanjuntak 2002), which, if relevant, would put this individual into a pre-Neolithic cultural context. But a direct AMS date on a rib fragment of 3053 ± 65 cal yr BP or 2987-3118 cal BP (AA96775) was obtained during research carried out by Noerwidi, courtesy of Greg Hodgins at the NSF-Arizona Laboratory in Tucson and the Indo-Pacific Prehistory Association. This date is clearly much younger than the first and corresponds to the Neolithic period. The bone dating result makes SK5 one possible example of a human skeleton from the Neolithic period of Java, which is a very rare find.

Figure 4. The human skeleton of Song Keplek 5. Photo: the authors.

Discussion of biological and cultural data

This discussion will include the aspects mentioned under 'Methods' above, with relevant comparisons to ethnographic records from recent Indonesian populations where relevant (especially for betel chewing tradition in Javanese populations, e.g. Rooney 1993; and see Krais *et al.* this volume). Postmortem taphonomical processes, however, will not be discussed in detail here, as the particular excavation history of this specimen, which was removed in a whole block of sediment and excavated several years later, complicates taphonomic analysis.

Estimation of age

Seven age classes are commonly used to classify human osteological remains: foetus (before birth), infant (0-3 years), child (3-12 years), adolescent (12-20 years), young adult (20-35 years), middle adult (35-50 years) and old adult (50+ years) (Buikstra and Ubelaker 1994; White and Folkens 2005). Bone development may differ considerably from one individual to another. As a result, age estimates are expressed as ranges, and should provide as many indicators as possible from a single set of remains (White and Folkens 2005). For SK5 we were able to examine five characteristics frequently used for age estimation: dental eruption, maxillary teeth attrition, mandibular teeth attrition, maxillary suture closure, and epiphyseal closure. Due to the condition of preservation of the remains, it was not possible to observe cranial suture closure or pubic symphyseal surface.

The dental crowns of the two mandibular M_3 are already fully erupted. This means SK5 was in the middle adult range, and probably already more than thirty-five years old, based on Ubelaker (1989) and White and Folkens (2005). Regarding maxillary attrition, it was not possible to observe the right P^3, C, I^2 and the left C and I^2 because of removal processes. It was also not possible to observe the left and right I^1 for this purpose because of ablation processes. Observation of the casts of left and right M^3 show an almost complete condition, with just slight abrasion on the buccal cusps. Left and right M^2 have slight attrition on all cusps. Left and right M^1 have medium attrition of both lingual cusps. Left P^3, and left and right P^4 have medium attrition of their occlusal surface. Based on these conditions, SK5 is at maxillary attrition level H, which corresponds to a forty to fifty year age range based on Lovejoy (1985) and White and Folkens (2005).

Regarding mandibular attrition, left and right M_3 show an almost intact condition, with only a slight abrasion of buccal cusps. Left and right M_2 have medium attrition of buccal cusps. Left and right M_1 have medium attrition of buccal cusps and slight attrition of lingual cusps. Left and right P_3 and P_4 have medium attrition of their occlusal surfaces. Left and right C have medium attrition of their occlusal surfaces. Left and right I_2 and I_1 have strong attrition of their occlusal surfaces. Based on these conditions, SK5 is between mandibular attrition levels G and H, which would correspond to an age of around forty years based on Lovejoy (1985) and White and Folkens (2005).

The incisive suture, which separates maxilla and premaxilla, is completely fused (score 3). The anterior median palatine suture, which separates the left and right maxillae between the incisive foramen and the palatine bone, shows an early phase of fusion (score 1). The transverse palatine suture, which separates the maxillae and palatine bones, is not fused (score 0). The posterior median palatine suture, which separates the left and right palatine bones, could not be observed. Based on these observations, SK5 presents a composite score of four, meaning that the individual was 41.1 ± 10 years old, based on Mann *et al.* (1991) and Meindl and Lovejoy (1985). The epiphyseal closure observations show complete fusion, in the adult range.

To summarize, the observations of five different characteristics (dental eruption, maxillary attrition, mandibular attrition, maxillary suture closure, and epiphyseal closure) suggest that the SK5 individual was around forty years old at time of death, a younger age than the previous estimation by Widianto (2002).

Determination of sex

For sex identification we observed the characteristics of the pelvis (greater sciatic notch) and skull. There are five morphological features from the skull which are useful in determining sex: nuchal crest, mastoid process, supraorbital margin, supraorbital ridge or glabella, and mental eminence. In all cases,

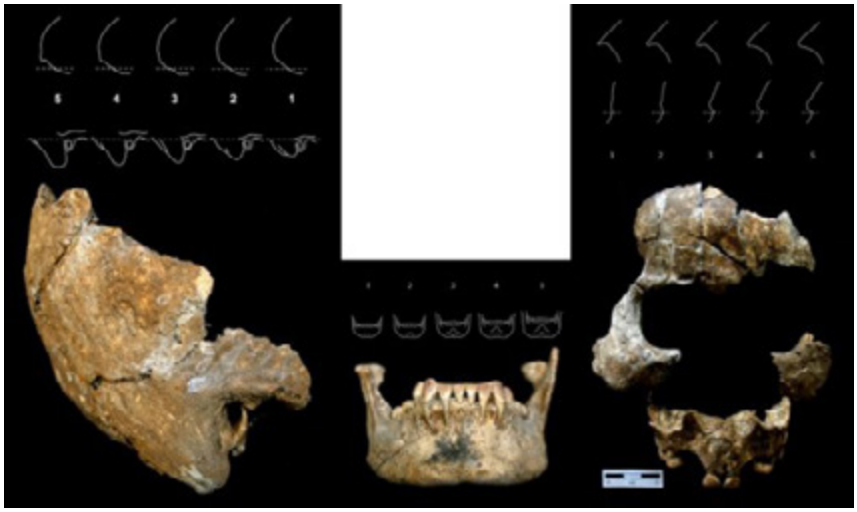

Figure 5. Sex determination on SK5 cranio-mandibular characteristics. Photos: the authors.

Figure 6. Morphology of the greater sciatic notch of the pelvis of SK5. Photo: the authors.

a five-point scale is used to indicate a value of sex, with the feminine feature at the lower (1) and the masculine feature at the upper end of the range (5) (Buikstra and Ubelaker 1994). The results for SK5 are as follows (see Figure 5): nuchal crest – level 3; mastoid process – level 2; supraorbital margin – level 3; glabella – level 3 (but uncertain due to damage); mental eminence – level 3. From these observations of skull morphology, it is hard to determine the sex of SK5, because it has values of level 3 for four of the five characteristics. The only characteristic which shows a more feminine value is the mastoid process.

The pelvic area exhibits the greatest sexual dimorphism and can be regarded as the 'gold standard' for sexual discrimination in skeletons (Klepinger 2006). A very long inventory of innominate (*os coxae*, pelvic bone) traits has been demonstrated to have significant differences for males and females in all populations (*ibid.*). The greater sciatic notch of SK5 shows a large (wide) angle. It would correspond to grade 2 according to Buikstra and Ubelaker (1994) (Figure 6). We conclude that SK5 shows a female morphology for this characteristic. To summarize, the observations related to sex determination made on six cranio-mandibular and pelvic characteristics of SK5 suggest it is possibly a female individual, supporting the previous determination by Widianto (2002).

Ancestry

In studying remains of unknown identity, forensic anthropologists usually attempt to estimate the ancestry of the individual or the group with which this person would likely have been identified in their community (the so-called 'ethnic identity' of the individual). This information can be useful to law enforcement in attempting to narrow the search for the identity. It is important, however, to recognize the social dimensions of these categories and not to confuse this effort with past typological classifications that suggested greater biological grouping than actually exists (Ubelaker 2008: 52).

In forensic anthropology, the estimation of ancestry is accomplished through observation of characteristics such as dental morphology and features of the facial skeleton, and through measurements, usually with discriminant function analysis. The former approach has been augmented by increased attention to a variety of anatomical features that display variation (Gill and Rhine 1990). The latter approach has grown primarily through the acquisition of measurements from larger, more

diverse samples, with special effort aimed at the needs of the forensic community (Ubelaker 2008: 52). This second kind of approach has been applied to the SK5 specimen based on work by Noerwidi (2012).

Several cranio-dental morphologically qualitative features, which are commonly used for observation of population affinity, are well preserved in SK5 (Figure 7):

- frontal orientation is relatively vertical (although broken, so not certain)
- facial prognatism is reduced
- the *arcus supraorbitalis* is not strongly marked
- the occipital is relatively flat in the lateral view
- there is no prelambdatic depression
- the maxillary roof is not deep
- the *alveolar planum* is not thick
- there is dental reduction in form and size
- a shovel shape is seen in the maxillary incisors, at level 5 of 6 (after Scott 1972).

Figure 7. Dental and mandibular characteristics observed for ancestry estimation. Photos: the authors.

In a comparison including some prehistoric human remains from Indonesia, Widianto (2002) suggested that Song Keplek 5 has 'Mongoloid' or (East) Asian population affinities based on cranial morphological qualitative (non-metric) characteristics. From our re-observation of cranio-dental character, we agree with this previous suggestion. This hypothesis was already tested in a previous study through morphometric quantitative comparisons with several prehistoric and recent samples from Java and surrounding areas (Noerwidi 2012).

Estimation of stature

The height (stature) of the human body is correlated with limb bone lengths across all ages, which allows osteologists to reconstruct an individual's stature from different skeletal elements. Long bones in good conservation condition which could be used for the reconstruction of the stature of SK5 included the humerus, radius, ulna, tibia and fibula. The measurement used for this reconstruction is the maximal length of each long bone (M1). The stature estimations obtained with different regression and correlation formulae proposed by various authors are shown in Table 1. Exploration of stature estimation by different methods of measurement and formula suggests that there are some extreme values, such as 180.296 and 158.34 centimeters by the humerus formulae, and that measurement by fibula formulae has the lowest deviation, around 166.480 ± 3.25. Based on measurements of the humerus, radius, ulna, tibia, and fibula with different formulae, we suggest the individual had a stature of approximately 166 centimeters.

Pathology and health

Paleopathology is frequently defined as the study of ancient disease (Waldron 2008), a seemingly straightforward characterization, which nonetheless requires clarification of the terms 'disease' and 'ancient'. 'Disease' is generally defined as 'an impairment of health or a condition of abnormal functioning' (Buikstra 2010: 395). Thus, paleopathologists study not only infectious diseases, but also a myriad of other conditions that affect health (see Buikstra 2010).

Table 1. Stature estimates for SK5

Stature (cm) after Trotter (1970, in White and Folkens 2005): humerus: 171.918 +/- 4.25; radius: 166.252 +/- 4.60; ulna: 169.670 +/- 4.66; fibula: 166.480 +/- 3.25.	Mean 168.58 cm
Living stature, using the formula for females without specific population affiliation (Pearson 1899, in Martin and Saller 1914): humerus 71.475 + 2.754 = 166.7634 cm; tibia 74.774 + 2.352 = 166.502 cm; radius 81.224 + 3.343 = 160.7874 cm; humerus + radius 69.911 + 1.628 = 150.0398 cm; humerus 70.542 + 2.582 + radius 0.281 = 166.567 cm.	Mean 162.124 cm
Body length, using the formulae for Javanese females based on the maximal length of long bones (Bergman and Hoo 1955): humerus (left) 502 + 3.76 = 1802.96 mm = 180.296 cm; radius (left) 762 + 3.68 radius = 1637.84 mm = 163.784 cm; ulna (left) 449 + 4.68 = 1689.2 mm = 168.92 cm; tibia (right) 520 + 3.08 = 1721.2 mm = 172.12 cm; tibia (left) 498 + 3.16 = 1698.8 mm = 169.88 cm	Mean 171 cm
Body length, using the formulae for Javanese females based on the maximal length of long bones (Bergman and Hoo 1955): 101.5 + 0.98 subdeltoid circumference humerus (r) = 158.34 cm (= lower); 95.9 + 0.79 mid-shaft circumference femur = 163.05 and 164.63 cm (= higher)	Mean 162 cm

The proper analysis and interpretation of trauma in skeletal remains originates with the classification of injuries according to their predominate characteristics, that is: the ossification of soft tissues; extrinsically-induced abnormal shape or contour of a bone; dislocation (the displacement of one or more bones at a joint); and fracture (any break in the continuity of a bone) (Lovell 2008: 341-342). From the observation of bones for morphological anomalies, we identified some potential pathologies which inform on the health condition of SK5. Infectious disease is suggested, related to anomalies found at the superior aspect of the right patella, as well as at the lateral aspect of the left second metatarsal (Figure 8), and physiological stress is indicated, related to a long and oblique groove identified on the anterior aspect of the left femoral diaphysis (Figure 9).

These observations suggest SK5 suffered some infectious disease which affected her physiological condition, including a severe infection of the right patella, which shows a deep hole in its superior part. It is difficult to know exactly what kind of infection this is related to, but from a biomechanical point of view, the patella is very important for the mobility of the lower limbs, and SK5 may have more heavily used her left leg. This could be an explanation for the anomaly observed on the left femur which could correspond to a particular stress at the level of attachment of the *vastus lateralis* muscle (Figure 9).

Cultural practices: cranio-dental modifications and funerary practices

Culturally-related modifications of the cranio-dental morphology were identified on SK5, including tooth removal, severe attrition, and traces of betel chewing.

Dental removal is seen of the upper right I2, C, and P3, as well as the left I2 and C. Intentional dental evulsion is suggested by the closure of corresponding maxillary alveoli, which happened antemortem (during the life of the individual). This evidence is also supported by the corresponding inferior teeth (right C and P, as well as left C), suggesting a very limited degree of attrition, corresponding to grade C of the attrition scale (Lovejoy 1985), which suggests dental attrition corresponding to an age of only eighteen to twenty-two years. Based on this observation, we suggest that the evulsions occurred when SK5 was in late adolescence or a young adult. This practice resembles initiation rituals which are still found in some Indonesian populations, and were still practiced on Java Island, with different modifications, until at least a few decades ago according to oral history (Koesbardiati and Suriyanto 2007).

Figure 8. Infectious disease is suggested from characteristics on the right patella (left), and the left second metatarsal (right). Photos by the authors.

Figure 9. Physiological stress on left femur (above, both pictures). Photos by the authors.

Extremely severe attrition is observed on both maxillary central incisors. The dental crowns are reduced to around half their natural (original) height. This attrition is much stronger than the attrition of corresponding mandibular incisors and may correlate with the dental ablations (evulsions) seen (i.e. compensating for the lost teeth), and thus also correspond to initiation rituals, or it may correspond to specific para-masticatory use of those teeth.

Interpreted betel (*Piper betel*) chewing traces were observed on the buccal and lingual surfaces of almost all the teeth (but not evident on the right molars). In some ethnic groups of Indonesia, the betel chewing tradition uses betel leaf (*Piper betel*), areca nut (*Areca catechu*) and slaked lime, and may contain tobacco (after the colonial era) (Reid 1985). Based on ethnographical traditions in Indonesia, one function of betel chewing is to show friendship (Rooney 1993). All of the pre-colonial materials originate from tropical Southeast Asian environments. Other substances are often added to the betel-chewing tradition, including spices such as cardamom, cloves, aniseed, and mustard, or sweeteners according to local preferences (Zumbroich 2009). The properties of the areca nut relevant to betel chewing are alkaloids and tannin. These alkaloids give a red color to the saliva, teeth and faeces (Rooney 1993: 27). The red color on the tooth surfaces may be caused by areca nut (*Areca catechu*) and Indonesian gambier (*Ucaria gambir*) (Figure 10).

Similar patterns of dental removal on the lateral incisor and/or canine, with red coloring are also found in the Caruban Skull from Central Java (classic period), skeletons XXVII and XXXII from the Gilimanuk site, Bali (early centuries AD), and specimens from Liang Bua, Lewoleba and Melolo in Flores and neighboring islands (early centuries) (Jacob 1967; Soejono 1977; Koesbardiati and Suriyanto 2007). From mainland Southeast Asia, the same pattern of these dental modifications is also found in skeletons from Phum Snay and Phum Sophy, Cambodia, from AD 700 (Domett *et al.* 2011; see also Krais *et al.* this volume). It also occurs in Neolithic China (Dawenkou) and Taiwan (Pietrusewsky *et al.* 2014); in fact, it is very widespread in eastern Asia. This comparison suggests that Song Keplek had cultural connections with those regions.

Figure 10. Traces of interpreted betel nut chewing on the SK5 mandible (right), and the ethnographical tradition of betel nut chewing in Javanese people (left). Photos by the authors.

Funerary practice

Funerary practice comprises the complex of beliefs and practices used by a culture to remember the dead. In archaeological contexts, when the data left are very fragmentary, we cannot reconstruct all the kinds of ritual correlated to the funerary practice. Nevertheless, funerary customs as seen in archaeology vary widely between cultures, and between affiliations within cultures, and are a very good indicator of 'cultural identity' in an archaeological context (Lorentz 2015). In this study, we have collected information corresponding to the funerary practices represented by the SK5 individual, related to orientation of the skeleton, taphonomy, and other archaeological contextual information.

SK5 was a primary straight burial, with supine position. The orientation was east to west, with the head at the east, face upward, at 105 centimeters below the cave surface, and the feet at the west, 120 centimeters below the cave surface. The right and left arms were folded crosswise on the chest (Widianto 2002). The left arm was placed above the right arm (Noerwidi 2012).

The corpse was probably placed in a narrow burial pit as indicated by the preservation of smaller components of the skeleton (finger bones, for example) in their original anatomical position; also, a narrow pit was indicated at the level of the feet, lower limbs long bones and humeri. But the exact characteristics of the burial pit could not be observed during the excavation process (Détroit 2002). The positions of both clavicles, which were rotated at an angle of almost 90° from their original positions, may indicate that the corpse was tied before being buried (Figure 11).

One faunal bone spatula was found in association with the skeleton (just north of the skull). Some stones were placed above the skeleton. Several other animal bones were also found, for example several *Cervidae* teeth and one partial *Cercopithecidae* face on the left side of the chest, under the right hand of the deceased (Widianto 2002; Détroit 2002).

Conclusion

The SK5 skeleton is possibly female and was about forty years old when she died. She had a stature of around 166 centimeters, and a 'Mongoloid' or Asian population affinity based on her morphological qualitative (non-metric) cranio-dental characteristics. She had some infectious disease which affected her physiological condition, and an abnormality in her right leg might have stimulated her to use her left leg more for mobility. She was buried in a primary straight burial, with supine position, head to the east with face upward, and feet to the west. Her arms were folded across her chest, with the left arm located above the right arm. Her corpse was probably tied before being put into a narrow burial pit, although the edges of this pit could not be found through excavation. A bone spatula and some stones were placed above the skeleton, and some animal teeth and bones may be identified as burial gifts for SK5 during her funerary rites.

SK5 had dental mutilation on her upper right (I2, C, P3), and left teeth (I2, C) when she was eighteen to twenty-two years old, and dental ablation on both medial maxillary incisors, possibly showing an initiation ritual tradition, similar to those still found in some ethnic groups in Indonesia. She had a habit of betel chewing, showing traces on almost all buccal and lingual surfaces of her teeth, except the right molars. Similar patterns of dental removal and red coloring found in Indonesia and the mainland of Southeast Asia (e.g. Krais *et al*. this volume) show a cultural connection between the regions.

This study aimed to improve our understanding of living and dying in the later Holocene, and possibly the Neolithic period, during the initial Austronesian occupation on Java Island. SK5 is a rare specimen found on Java with a possible date from and correlation with Neolithic culture, and the continued results of our osteo-biographical study of this skeleton and others will provide key information regarding Holocene cultures in the area, and the reconstruction of ethnogenesis for the Javanese people in particular, and for Indonesians in general.

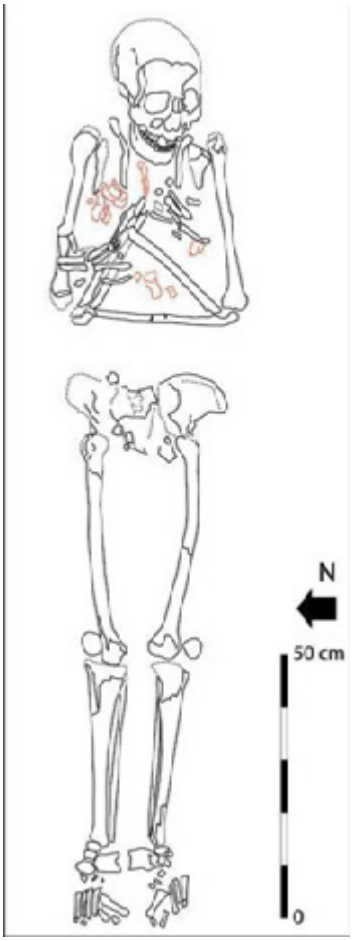

Figure 11. Position of SK5 skeleton, with some animal bones (in red) (Détroit, 2002; used with permission).

Acknowledgments

We would like to acknowledge the EurASEAA committee, especially Helen Lewis, and are grateful also to Damien Huffer, who give the first author the opportunity to join the EurASEAA14 conference. Our special gratitude goes to Peter Bellwood at ANU, Greg Hodgins in the NSF-Arizona AMS Laboratory, and the Indo-Pacific Prehistory Association's Accelerator Mass Spectrometry Outreach Program for Noerwidi's radiocarbon date. We are very grateful to Dominique Grimaud-Hervé, and Florent Détroit for their constructive comments on our paper, and to an anonymous referee.

Probable prehistoric Southeast Asian influences in New Guinea? New archaeological and anthropological approaches to former axioms

Henry Dosedla

When exponents of diffusionist theories postulated ideas concerning cultural influences linking the Melanesian archipelago with Southeast Asia, this hypothetical approach had no other basis than systematic comparisons of various striking similarities between distinct archaeological artifacts and their geographical distribution patterns in the two regions. Their assumptions were mainly based on the occurrence of the so-called quadrangular axe type, megalithic structures, sculpted stone items and corresponding features of anthropological relevance. These ideas were backed up by the discovery of the prehistoric Wahgi civilization of interior Papua-New Guinea, and by further archaeological and related anthropological investigations carried out there since the early seventies. These and the amount of more recent archaeological data are increasingly providing additional evidence for theoretical concepts first developed by Heine-Geldern and Riesenfeld, prominent members of the Vienna School of the last century, evoking new insights and debates on this topic.

Introduction

Since the first hypothetical suggestions during the early decades of the twentieth century of supposed cultural contacts between Southeast Asia and New Guinea, these ideas were significant for then-prevalent general theories of transcultural diffusionism, which had been proposed by leading anthropologists (e.g. Boas 1940; Frobenius 1898; Haddon 1913) and archaeologists (e.g. Childe 1951). Among these, the so-called Vienna School, represented by Schmidt (e.g. 1972) and Koppers (1952) with their 'culture circle theory', had great influence, especially on early research in Oceania, including on anthropologists such as Bühler (1962), Wirz (1959) and Speiser (1946), all from Switzerland. Some of the theorems published by Austrian anthropologists Robert Heine-Geldern (1928, 1932) – who was my professor in Vienna – and Alphonse Riesenfeld (1950a, 1950b, 1951) were based on systematic comparisons of numerous carefully-collected data, with their distinct geographical distribution clearly showing significant patterns of diffusion routes linking continental Asia and the adjacent archipelagos. Although these were published sixty years ago and were solely based on a couple of striking but perhaps just coincidental similarities, these data have since increased considerably in number, and subsequent interpretations have gained support through methodological improvement. The preliminary datasets listed by the Viennese scholars some decades ago were limited: most parts of interior New Guinea were still in their early years of anthropological fieldwork and first archaeological excavations. The present state of research offers the opportunity to develop new interpretations that may assert the former diffusionist axioms.

Material indications

Stylistic

Apparently most of these scholars' suppositions of probable cultural links between Southeast Asia and New Guinea were based on rather incidental although striking similarities in art styles, such as the so-called Korwar style of northwest New Guinea (Bühler 1962), which slightly suggests Southeast Asian influence, or the significantly curved noses of Sepik wood carvings in some way resembling elephant trunks, which were interpreted as being influenced by Ganesha figurines derived from trade imports (Wirz 1959). But even later and more advanced analyses of abundant examples comparing Dongson, Lapita and Sentani material have not stopped the debate over direct influences between northwest

New Guinea and Southeast Asia in regard to art styles, dating back to prehistoric periods (Golson 1972) especially with regard to the Admirality Islands (Badner 1968).

Bronze artifacts

Though bold suppositions once made of Bronze Age prospecting parties visiting New Guinea have been dismissed, the growing number of bronze objects that have been discovered throughout New Guinea, including a case from Irian Barat (Ambrose 1988), is still providing evidence of trade links between the island and Southeast Asia, but only two of these finds have been accurately dated, and these still do not provide a more detailed explanation of the nature of any maritime links (Wright *et al.* 2013).

While most of the bronze artifacts scattered around New Guinea cannot be dated in any way, findings of bronze items from the Manus Archipelago have provided quite accurate chronological data, showing a surprisingly old age for maritime links (Ambrose 1988). Before the first archaeological excavations in interior New Guinea, the surprising number of bronze artifacts that were incidentally found there led to the interpretation, noted above, of some Bronze Age immigration by prospecting parties (Summerhayes 2007). Another explanation given was that these artifacts were brought by trading parties in exchange for bird's plumes, slaves, trepang (sea cucumbers) or other rare products (Schwerdtner Máñez and Ferse 2010) (Figures 1 and 2).

Undated bronze and brass weapons have been recorded from the northern coast of New Guinea in the Lake Sentani region (de Bruyn 1959; Solheim 1979), but could, according to Bellwood (1978: 266), have been brought in within the last 1500 years. Three Dongson drum tympani of the typical Heger type have been described from Lake Ajamaru at the far western end of the island (Heger 1902; Elmberg 1959: 79). Apparently local people had broken away the edges of the flat, circular tympani to provide small pieces of bronze which were then wrapped in bark cloth and worn as amulets. In the Kai Islands south of Lake Ajmaru another two Dongson bronzes have been classified as the 1 C Heger type, which according

Figure 1. Bronze kettle drum, fourth century C.E. B.P. Bishop Museum, Honolulu.

Figure 2. Bronze axe head; after H.R. van Heekeren (1958).

to the Chinese Buddhist inscriptions on one of them, suggests manufacture in the third century AD (Spennemann 1985: 168; Bernet Kempers 1988: 284). The oldest bronze item of a Melanesian context within the vicinity of western New Guinea is an ornament of soldered copper and bronze known from East Timor, with an uncalibrated date of 2,190 ± 80 bp (ANU-237) (Glover 1986: 153, pl. 36).

A review of previous radiocarbon dates for bronze-working in mainland Southeast Asia (Bayard 1986-1987: 126) indicates its establishment by the second millennium BC in Vietnam. According to the evidence for the introduction of metal to the eastern islands of the Indo-Malaysian archipelago it may be concluded that the Early Metal Phase associated with copper, bronze and iron may be dated from about 200 BC-AD 1000 (Bellwood 2006). Revealing evidence for the rapidity of early metal introduction to Melanesia is provided by a small piece of bronze excavated on Lou Island near Manus under a volcanic ash layer dated to 2100 BP, long before any appearance of metals in the eastern Indonesian islands (Ambrose 1988). Kennedy (1983: 116) states that: 'Whatever impediment existed in the first and second millennium BC to the transfer of metal from the southeast Asian mainland to the eastern islands fringe of the region, did not appear to deter a very rapid transfer of material across wide water barriers to the Bismarck Archipelago, 2000 km further to the east, by 100 BC.' She suggests that the maritime technology in the Admiralty Islands and Bismarck Archipelago at the time, and their long prehistory of canoe-based travel, probably aided in this rapid movement (*ibid.*).

To some extent, the range of this long-distance contact can be gauged by the distribution of obsidian from the Admirality Islands, which reached the distant islands of Mussau, New Ireland and even Vanuatu around three thousand years ago, together with the first arrival of pottery in these places (Summerhayes 2007). On the basis of obsidian dispersal, the eastern limit of the influence of the Admiralty Islands in the early first millennium BC extended some 3000 kilometers through New Ireland and the eastern Solomon Islands to Vanuatu, at the same time that obsidian from New Britain was being carried east as far as Fiji, 3700 kilometers from its source and across a 1000-kilometer water gap from the main islands to the west (Best 1987: 31).

Stone artifacts

Another significant indicator of supposed prehistoric migration is provided by numerous stone artifacts, with mortars, pestles and figurines having been ascribed to some still-unknown prehistoric population on New Guinea, and its interpreted affinity with the so-called Wahgi civilization, which, before the first excavations in the sixties, was not known to the Viennese diffusionists. According to them, this period predating Lapita was ascribed to 'stone using immigrants', who were also the bearers of the well-known 'quadrangular axe' (Riesenfeld 1950b). With the increased number of such objects being found, and their distinct distribution patterns being mapped, there is now evidence of the quite significant routes by which these items found their way from the northern coastal areas of New Guinea into the highlands.

While most of these stone mortars, pestles and club heads are scattered throughout the interior highlands as well as adjacent islands, they do not show any remarkable stylistic differences (Bulmer 1973). This applies also to the considerable number of anthropomorphic stone figures, which apparently belong to the same prehistoric period. Deriving from the distinct distribution patterns of rather crudely-shaped figures compared to figures with rather detailed shaping (Wiessner and Tumu 1998), it may be concluded that their center of origin was situated in the western part of New Britain (Figures 3-4). Since this was also the main source of obsidian which was traded across the sea towards the northeastern shores of New Guinea (Best 1987), it appears most likely that the distribution of stone figures also follows these ancient trade routes.

Ceramic artifacts

The question of ceramics in interior New Guinea, away from all known manufacture centers in the coastal regions, is far from any sufficient solution (May and Tuckson 2000), but distinct distribution patterns follow the same routes linking the northern coasts with the interior (Dosedla 2012c). While the so-called 'ceramic belt' consists of limited coastal areas of the island, including the Lower Ramu Plain, clay pots were traded inland along the river systems of the Keram and Ramu as far as to the Bismarck Range (*ibid.*). Apart from the question of as-yet unidentified potsherds found in some interior highland regions, there is also a rich modelling tradition using unfired clay, but not including pottery, throughout the highlands (Dosedla 2012a, 2012b), and it may be possible that New Guinean prehistoric ceramic traditions had a more expansive distribution than those of later periods.

Agricultural traditions

In addition to the increasing significance of distribution patterns of artifacts and of other material cultural indicators (e.g. megalithism and 'pseudo-megalithism' and related paraphernalia, including traces of some kind of sun cult; Megitt 1973), which have considerably increased in number and density through recent investigations, there are now additional distinctive types of archaeological data, as well as biocultural and linguistic indications of connections, and profound records of oral lore.

Prior to the archaeological discovery of the ancient Wahgi civilization, it was generally believed that technical innovations such as crop cultivation and animal husbandry or ceramics did not spread into interior New Guinea earlier than the arrival of the Lapita immigration wave, three thousand years ago (Blench 2014). Since it is now a proven fact that the Wahgi Valley may be regarded as the earliest center of tuber domestication nine thousand years ago (Denham and Haberle 2008), it may be proposed that many other cultural features of the island could also have an autochthonous origin, rather than being just imported ideas. In addition, the ways in which an ingenious invention like tuber cultivation spread from the New Guinean highlands to other regions in or even outside Oceania should also be explored. The distinct vegetation patterns of the island, marked by dense forestation interrupted by vast grassland regions, which are apparently of anthropogenic origin, clearly shows the impact of agricultural development over the course of prehistory (Robbins 1960; Allen 1970).

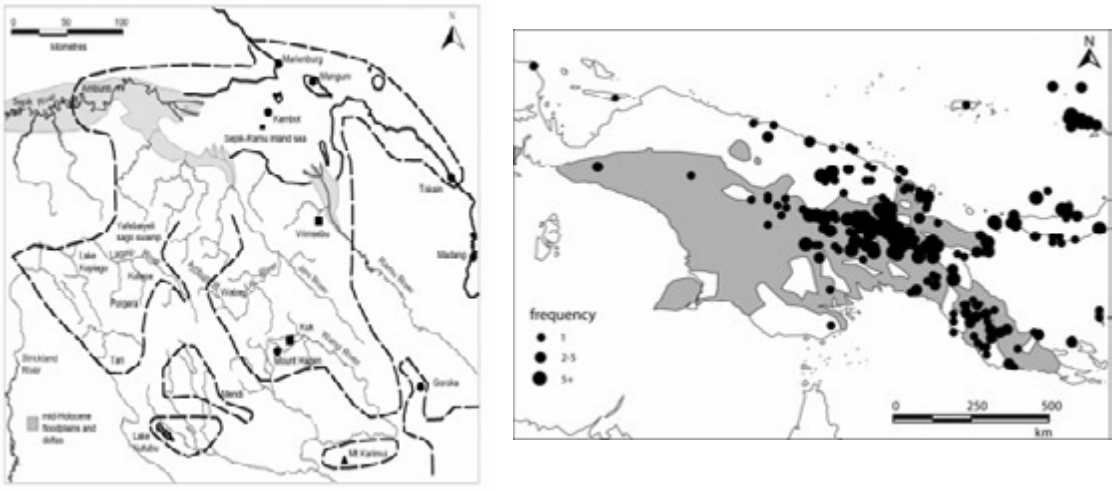

Figure 3. The most prominent migration routes of earliest settlement periods (top), and mortar and pestle distribution and frequency (bottom); after Swadling et al. *(2008).*

Figure 4. Location of the mid-Holocene Sepik-Ramu inland sea; after Swadling et al. *(2008).*

Regarding the presence of sweet potato, maize, tobacco and other crops of American provenience in New Guinea, the probable date of introduction and the probable distribution routes of which caused controversial debates fifty years ago, considerable research results have been gained in recent decades, shedding additional light on the historical links between Southeast Asia and Oceania (Spriggs 1985; Blench 2014).

Narrative and musical traditions

Regarding the many traditional myths and tales collected from all parts of New Guinea and the adjacent islands, and their affinity with the international tale type index by Aarne-Thompson (Uther 2004), many of these are clearly not only related to narrative structures seen on other continents, but most presumably related to those of Southeast Asia (Dosedla 2012b). Improvement of the general research situation during recent decades has been gained by increased access to many of the vernacular idioms, of which most anthropologists of the early periods were rather ignorant (Hooley 1964). A great amount of traditional oral lore has been collected and recorded, sometimes revealing considerable insights into the historical dimensions of tribal affairs – including distinct migration movements – dating back several generations, and these are to some degree supported by archaeological evidence (Dosedla 1977).

Another yet unsolved question is the matter of musical traditions throughout New Guinea, which show an intricate as well as revealing distribution pattern of numerous styles, thus modelling distinct 'soundscapes' with a great variety of musical instruments (Dosedla 2009). While these are dominated by various flute types and two main drum types, bamboo jaw harps and the so-called musical bow are also of significance and implicate continental origin (Dosedla 2012a).

Main routes in, to and from New Guinea

Extrapolation of the known 3000-kilometer range of obsidian from the Admiralty Islands to the west, through intermediate islands and the north coast of the New Guinea mainland, brings the Moluccas and the southern Philippines well within reach. Given their own circumstances of geographic isolation, coupled with a facility for ocean travel, it is more likely that the Admiralty Islands would be the home of active carriers of cultural items and influence, rather than the remote receivers of what visitors might bring. The mode of this involvement with the surrounding societies over the past three thousand years seems unlikely to have been unique in the region, since there was a widespread coastal sailing technology based on long outrigger canoes along the north coast of New Guinea up to historic times (Summerhayes 2007). Pottery was introduced into the Admiralty Islands, presumably from a source to the west, more than three thousand years ago (Kennedy 1983: 119), one of the earliest occurrences in island Melanesia. The small bronze item from Lou Island mentioned above is just another witness to the long-term, long-distance communication between the Admiralty Islands and surrounding Melanesia, and suggests a general western Melanesian facility to operate with ease within their whole archipelago.

According to the available evidence, distribution routes in New Guinea did not go along the inland mountain ridge running from west to east across the island, nor did they follow the southern coast line, but show distinct patterns of linkages between the northern coast and the interior, especially with

regard to the river valleys of the Sepik, Ramu and Markham. This pattern matches the most prominent migration routes of earliest settlement periods (Swadling *et al*. 2008) (Figure 3).

Links between the north coast and the interior were further facilitated in prehistoric periods by the Sepik-Ramu floodplain (Figure 4), which during the Pleistocene was a large saltwater inland sea, and then a lake, providing easier access to the highlands by water transport (Dosedla 2012c). Among the three marked main inland settlement corridors of the earliest periods of interior New Guinea – the Markham, Wahgi and Tari basins – there is archaeological evidence for a vast channel system plied by canoes, even in places where the recent population has not the slightest idea of boat building (Allen 1970; Dosedla 2012c). The same applies to present knowledge of the intricate networks of traditional trade routes, linking all parts of the island with each other, which apparently not only served for transporting trade goods, but also the spread of ideas, as seen in the case of cult movements, narrative and other oral elements, thus in fact providing general communication routes (Dosedla 1979).

The important cultural complex of the prehistoric Wahgi civilization, the main link between the central and coastal regions, has been shown through archaeological excavations to have used the river valleys of the Markham towards the east and the Ramu towards the north, both traditional trade routes until very recently (Bulmer 1969). At the time of excavation campaigns, large parts of the adjacent Enga Province and the Southern Highlands Province were still restricted areas with limited anthropological and a complete lack of archaeological research. Because of this, the cultural importance of the Tari Basin and its links across the Enga region towards the Sepik Valley are far from being recognized or understood. Despite this, this section of the highlands appears to be a missing link between coastal and possible overseas influences and remote interior areas (Swadling *et al.* 2008). Though no archaeological fieldwork has been carried out here yet, there are significant indications that this region might share a lot of distinct cultural features with the Wahgi civilization.

These preliminary impressions are also supported by a great amount of local oral lore, significantly with numerous narratives dealing with a past ancestral migration from the northwestern Enga Province towards the Wahgi Basin (Dosedla 1977). According to this narrative complex, a former settlement corridor must have existed in the basin between Mts Giluwe and Ialibu at a time when the present-day grasslands were heavily forested and before Lake Boona came into existence (Dosedla 2008). Distinct details of these narratives are apparently supported by excavation results from the Wahgi Basin, revealing the same significant succession of climatic changes, deforestation and recovery of vegetation patterns as reported from the Lake Boona area (Robbins 1960). According to local lore this was the place from which all the crops were distributed at the time when the various tribes were separated. Recent informants can still show a number of distinct places where indications of former settlements may be found, including a prominent mound reputed to be the place where the legendary ancestral chief was buried together with the giant eagle he used to ride (Dosedla 1977).

Conclusion

The important cultural complex of the prehistoric Wahgi civilization, the main link between the central and coastal regions, has been shown through archaeological excavations to have used the river valleys of the Markham towards the east and the Ramu towards the north, both traditional trade routes until very recently (Bulmer 1969). At the time of excavation campaigns, large parts of the adjacent Enga Province and the Southern Highlands Province were still restricted areas with limited anthropological and a complete lack of archaeological research. Because of this, the cultural importance of the Tari Basin and its links across the Enga region towards the Sepik Valley are far from being recognized or understood. Despite this, this section of the highlands appears to be a missing link between coastal and possible overseas influences and remote interior areas (Swadling *et al.* 2008). Though no archaeological fieldwork has been carried out here yet, there are significant indications that this region might share a lot of distinct cultural features with the Wahgi civilization.

Ancient settlement in the lakes area of East Java Province, Indonesia: the potential for archaeological research with public benefits

Gunadi Kasnowihardjo

Archaeological research on the ancient settlement patterns in the area of the lakes of East Java Province, Indonesia, is one attempt to realize the benefits of archaeological research for the public interest. This research explored how past societies lived in the area of the lakes, with the aim of providing valuable knowledge for contemporary residents of the area and future generations. Current social practices have reduced the quality of human life in the lakes region. This paper will present alternatives for sustainable living in the lakes region based on archaeological information.

Introduction

When did humans begin to occupy the lakes area in East Java? Why were they interested in occupying this area? These two research questions are what started interest in research on ancient settlements in the lakes region of East Java Province. Early research was initiated by Goenadi Nitihaminoto (2007), which is quite late compared to other countries, where research into the history of lake regions began *c*. 150 years ago. In Europe, for example, ancient settlement patterns show people living on lakeshores, with houses built on poles and piles of wood, such as have been found from the excavation of underwater sites (e.g. Menotti 2004: 15-16).

Settlement patterns around the ancient lakes in East Java are and were affected by the natural environment. Archaeological data from research in several lake areas such as Klakah, Gedang, Segaran, Bethok, and other lakes in East Java Province (Figure 1) show that the area has been occupied by humans since the Neolithic or earlier, based on finds of stone axes (Gunadi Kasnowihardjo 2010, 2015). The natural resources found in the region were apparently the reasons why our ancestors chose that location for their settlement. The areas surrounding the lakes are ideal locations for ancient human habitation, as is shown by the discovery of artifacts from Hinduist-Buddhist and early Islamic cultures. Even today, the lake area is still maintained as a residential location (*ibid*.).

Figure 1. Location of lakes in East Java Province: Grati Lake, Pasuruhan Regency; Klakak Lake, Lumajang Regency; Gedang, Segaran and Bethok Lakes, Probolinggo Regency. Source: GoogleEarth maps, accessed February 2020, altered by Gunadi Kasnowihardjo.

Natural phenomena observed during study of the East Java lakes, such as the shrinking and drying up of the Gedang

and Bethok Lakes, suggest that archaeological studies can be used with environmental data to compare shifting human behavior from the present back to prehistory (Gunadi Kasnowihardjo 2015). Such a study would need collaborative research involving multiple disciplines, looking at issues such as the role of human communities in the shrinking of lake water volume and environmental change. These studies are very important for present-day and future life – have local communities neglected and forgotten the wisdom that was taught by our ancestors? If we apply that local wisdom today we can have a positive impact for the life of both the present and next generations.

The shrinking of lake-water volume results in various impacts, such as the extinction of freshwater mollusk populations and reduced fishing grounds, as well as the reduced value of the beauty of the environment. Ecosystem degradation is the main factor decreasing lake-water volume, caused by human behavior that has abandoned the values of local wisdom in conserving the natural environment. Preserving the ecosystem is something that has long been taught by our ancestors, and if we can keep the lakes in good condition, as in the past, the ancient environment of lakes would be a hope for future generations. Both cultural and natural heritage are the ancestral heritage entrusted to the present generation to bequeath to the next generation, so we must preserve and minimize the use of lake water. We must realize that the future is an ancient lake . This is the essence of archaeological study of the past, which should be actualized and implemented in the present for the sake of the future.

Ancient lakes in East Java Province, Indonesia

The lakes in East Java can be classified by their basin types. Lake water is heavily dependent on rainfall, rivers, and springs out of the fracture wall cracks in the cliffs around each lake. The (genetic) lake basins generally have walls with a slope between 55-70%, composed of volcanic rocks. Radial fractures with relatively steep walls form a circle around each basin, and the presence of a volcanic belt dating to the late Pleistocene-early Holocene suggests that these lakes are the remnants of ancient volcano craters (Gunadi Kasnowihardjo 2015). After the inactive craters were covered by base and surface sediments, the basins filled with water, eventually forming natural lakes. Based on genetic classification, the lakes in East Java thus fit into the category of 'volcanic lakes' (*ibid.*).

Based on water flow characteristics, several lakes in the area have no outlets, and reduction of lake water in them is caused by evaporation, surface water temperature and circulation during the year. Klakah Lake is one which has an outlet; when the discharge of water is high enough it forms a river that is able to irrigate extensive agricultural land.

Ancient settlement research in the lakes area by the Archaeological Research Center of Yogyakarta began in 2007, pioneered by Goenadi Nitihaminoto, and since 2008 the author has continued that study. Several lakes in East Java have been investigated to date in two areas: Lumajang and Probolinggo.

Klakah Lake

Klakah Lake is located in Tegalrandu village, Klakah District, Lumajang Regency (Figure 2). Survey found a prehistoric stone axes, a rectangular stone enclosure, and megalithic stones which represent a local megalithic tradition. Apparently the Klakah Lake region has been occupied by people over a long time span, as evinced by the excavation of a brick structure identical to others known from the Hindu-Buddhist tradition, as well as findings from an old cemetery related to early Islamic culture in the region (Gunadi Kasnowihardjo 2010).

Surface survey and excavation of some test pits show that findspots of archaeological artifacts surrounding Klakah Lake are on relatively flat land, and relatively close to the freshwater source. A surface survey at

the Jatian hamlet produced similar indicators; excavations there found the remains of temples of brick structures, a fragment of a stone axe, and fragments of ceramics (Goenadi Nitihaminoto 2007).

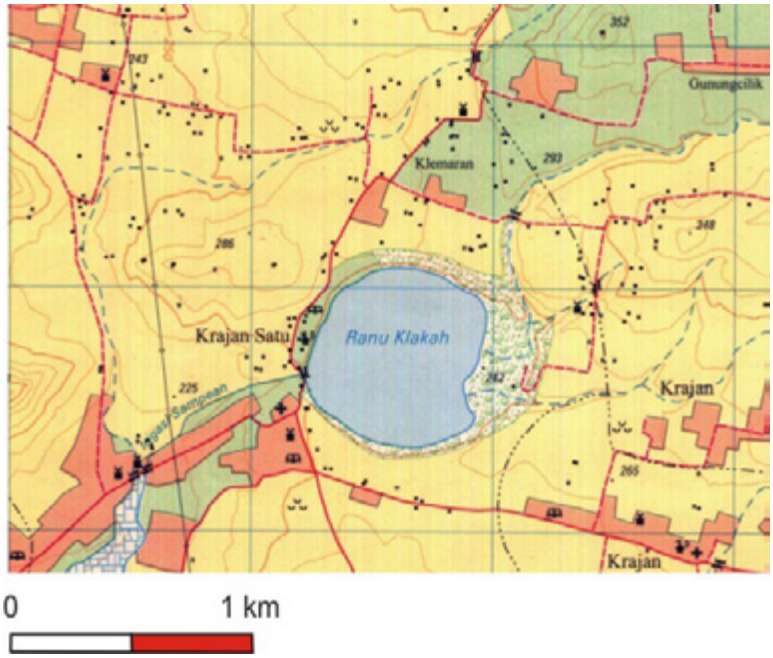

Figure 2. Location of Klakah Lake, amended by the author after a topographic map created by the U.S. Army in 1935.

Gedang Lake

Exploratory research in the area of Gedang Lake, in the village of Ranu Gedang, Tiris District, Probolinggo Regency (Figure 3), included surface survey followed by excavations, with a purpose of looking for indicators of ancient settlement concentrated in the area around the lake. A geomorphological survey showed the area around the lake to be relatively flat land. The surface water of the lake was then at eighty meters below the present ground surface, with terraces found at the edge of the lake, and spring water sources around the lake. The survey found artifacts such as a pickaxe 'produce square', a Chinese coin, freshwater shell remains, mortar stones and a megalithic tomb, as well as several sources of local information about the discovery of other artifacts (now sold by their finders), and about the values of Gedang Lake indigenous communities, mainly associated with forest management and a freshwater source (Gundai Kasnowihardjo 2015). Besides pottery fragments, there were no other findings from excavations around this lake. A geological excavation revealed stratigraphy showing the area around Gedang Lake was affected by volcanic eruption of Mount Lamongan, the only volcano close to the region.

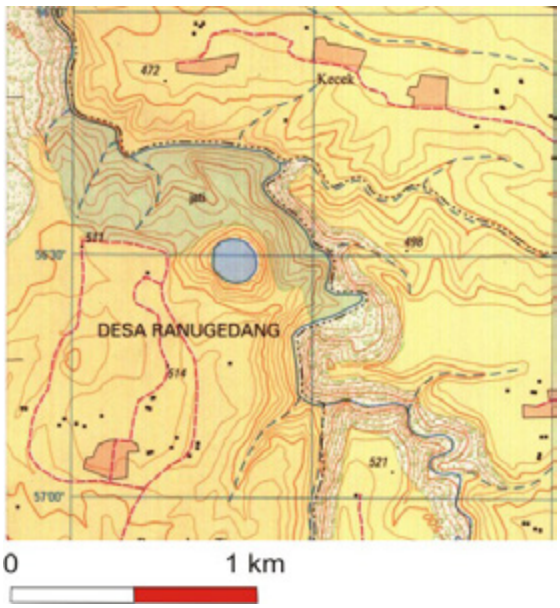

Figure 3. Gedang Lake location, amended by the author after a topographic map created by the U.S. Army in 1935.

Based on the results of the studies it can be concluded that the conditions around Gedang Lake allow the area to function well for agriculture and settlement. The finding of the stone axe and mortar, Chinese coin, and ceramics found by local people in farmland near the lake, suggest ancient settlement. Excavation finds included several fragments of thin and plain pottery, estimated to be Majapahit pottery. Some subsistence evidence is seen by the discovery of freshwater mollusk shells, which are thought to be leftovers from peoples who lived around the lake. An informant known as Ponandi reported that until the 1980s people around Gedang Lake fished for freshwater mussels in the lake.

The continuing importance of some sites is shown by the discovery of a stone monolith, marking an

ancient grave, and believed by the local people to be the tomb of their ancestor. The tomb complex is situated not far from the excavation site and up to now is used as a communal burial.

The relationship between society and the natural environment in general can be seen from existing beliefs or convictions about the preservation of forests that have been understood for generations. Preservation of forests will affect the whole environment, especially the conservation of lakes and other freshwater sources. In an interview, one informant (Mr. Sumindar, sixty-five years old, former elementary school principal at Ranugedang, 7 April 2008, personal communication) said that deforestation or illegal logging in the region began to be felt since the 1960s, under the old order pioneered by the Barisan Tani Indonesia (BTI), and that since then the community discussed the preservation of indigenous forest thinning (Gunadi Kasnowihardjo 2008, 2010, 2015).

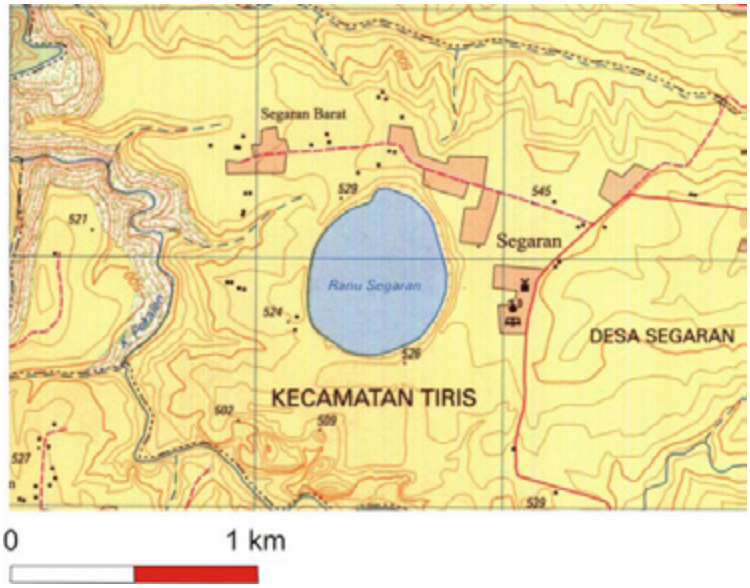

Figure 4. Segaran Lake location, amended by the author after a topographic map created by the U.S. Army in 1935.

Figure 5. Neolithic finds collected by local people. Source: Documentation of Balai Arkeologi D.I. Yogyakarta.

Segaran Lake

As in the other areas, survey and excavation at Segaran Lake found it to have relatively flat land contours (Figure 4), freshwater sources, and a 'tomb of the ancestor'. Ancient settlements were found on the north side of the lake, on relatively flat land. The location is now the western part of Krajan hamlet, where prehistoric artifacts including stone axes (*lightning teeth*) were found (Figure 5), along with a freshwater source, and the grave of Segaran village ancestor, all of which indicate long-term settlement. The utilization of both lake and freshwater resources by the people living around the lake up to today suggest that data on natural resources would be useful, as would ethnographic analogy (Gunadi Kasnowihardjo 2009, 2010).

Bethok Lake

Ancient settlement pattern research was conducted in the area of Bethok Lake in 2010-2011 (Figure 6), covering both the northern and southern parts of the lake. The results of 2010 in the north included the finding of a stone axe, stone mortar and stone grinder, a toponymy study, the recording of the tomb of the ancestor, a survey of freshwater resources, and the recording of the relatively flat landscape. Excavation activities did not find any significant data; the location of the

excavation area 'Pao Taber' was swept from the cold lava from Mount Lamongan. In 2011, research concentrated on the southern part of Bethok Lake, especially in Krajan hamlet, and included surveys and excavations. Survey activities found, among other things, stone adzes, terracotta beads and fragments of pottery (see Gunadi Kasnowihardjo 2012a, 2015; Figure 7), and recorded the distribution of the old cemetery and *punden* (praying location for ancestor worship). The results of the excavations included additional pottery fragments. The findings were that Krajan hamlet saw ancient settlement from the Neolithic period, continuing into the present-day.

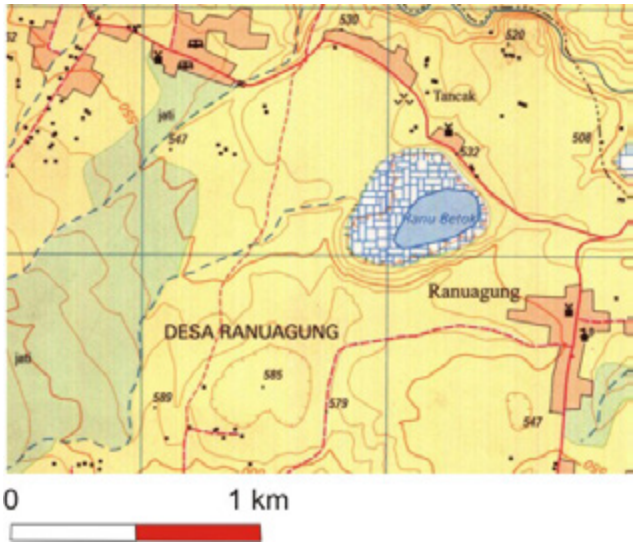

Figure 6. Bethok Lake location, amended by the author after a topographic map created by the U.S. Army in 1935.

Figure 7. Neolithic stone adzes. Source: Documentation of Balai Arkeologi DIY.

The geological survey found that the gneiss rock types are physically (visibly) similar to stone axe material seen locally. To ascertain whether the material was from this area, petrographic analysis was conducted of gneiss samples and samples from the stone axe materials by the Petrographic Laboratory Department of Geology, Faculty of Mineral Technology, Pembangunan Nasional University (UPN) 'Veteran', Yogyakarta. This study found that the main mineral content of the stone axe and gneiss rocks was different, so the raw material for the stone axes found comes from other areas. The results of petrographic analysis of pottery samples concluded that the ancient pottery from the excavations and pottery still made by local people have the same material (Gunadi Kasnowihardjo 2010, 2011, 2015).

Culture remains by the lakes throughout time

General concepts in determining a location for settlement are influenced by several factors that have relevance to environmental conditions, such as the availability of freshwater, land and landscape conditions, availability of food or nutritional resources, and accessibility (Subroto 1995). This was also found to be relevant at the lakes area in East Java. Models of settlement at the lakes area have shown that human settlements were not on edge of or immediately around the lakes, but in places that are relatively far from the lake, on land that is relatively flat and near freshwater sources. This is different to the models of ancient settlement patterns in lake regions elsewhere in Indonesia, where people built their houses on the waters of the lake (floating houses), such as at Tempe Lake, South Sulawesi (Naidah Naing 2010), or on the banks and around the lake, such as at Toba Lake, North Sumatra (Setiawan 2010).

With their culture humans can not only harmonize with their environment but can also take advantage of their environment for survival. Our ancestors gave a lot of examples of how to manage the natural environment: we have seen how they learned by doing and perceiving their environment, actualized into

formal behavior, and then inherited from generation to generation, so that their life was sustainable. Natural law is a universally applicable culture that is seen as local wisdom or local knowledge. People living in the lakes area of East Java were able to survive in their environment over time, as characterized by the features of their cultures.

Neolithic cultural traditions

Neolithic culture in Indonesia was classified by R.P. Soejono as the cultivation era. The technology developing at the that time was stone tool-making technologies producing stone axes, obsidian artifacts and arrowheads, along with bark beaters and pottery (Soejono 2008). Finding stone adzes in areas such as Klakah, Gedang, Segaran and Bethok Lakes suggests that there was occupation of the East Java lakes area during the Neolithic (Gunadi Kasnowihardjo 2015). Stone axes were made in different sizes, from four to twenty-six centimeters, with the smaller versions serving to cut wood or used in the processing of agricultural land (after Soejono 1984, 2008). The end of the stone axe culture varies in Indonesia; in Papua, for example, people still used a hatchet-shaped stone tool for daily activities until the 1960s, while elsewhere people replaced these with tools made of iron or other metals. The large stone axe found in Bethok hamlet, about 200 meters north of Bethok Lake, which is half broken with retouch found on the sharp part of the axe, suggests that it was used as daily equipment (Gunadi Kasnowihardjo 2015). The present-day Lumajang and Probolinggo communities in general refer to these artifacts as *Gege Kelap* (Maduranese language), while Javanese people call them *Untu Bledhek*, both meaning 'lightning teeth', because they look like a human tooth, and are often found after rain. Some of the informants in this study stated that lightning teeth were occasionally found in the tops of coconut trees charred by lightning strikes.

Peoples settled in the lakes today believe that the stone axe has magic or supernatural powers. One of their beliefs is that when a stone axe is placed in a rice box, the rice will last longer and not run out quickly. Relatively small stone axes are still often used to sharpen scythes, and they are always carried and used as whetstones in this way.

Hindu-Buddhist culture

The remains of Hindu-Buddhist culture found from this research are quite significant, including the remains of the foundation of a brick temple building in Jatian hamlet, Tegalrandu village, Klakah District, near Klakah Lake (Gunadi Kasnowihardjo 2015). There is no previous information about the temple remains, either from local sources or the literature. The excavations in the stone enclosure found an interpreted brick floor, and outside the stone enclosure were other structural remains interpreted as

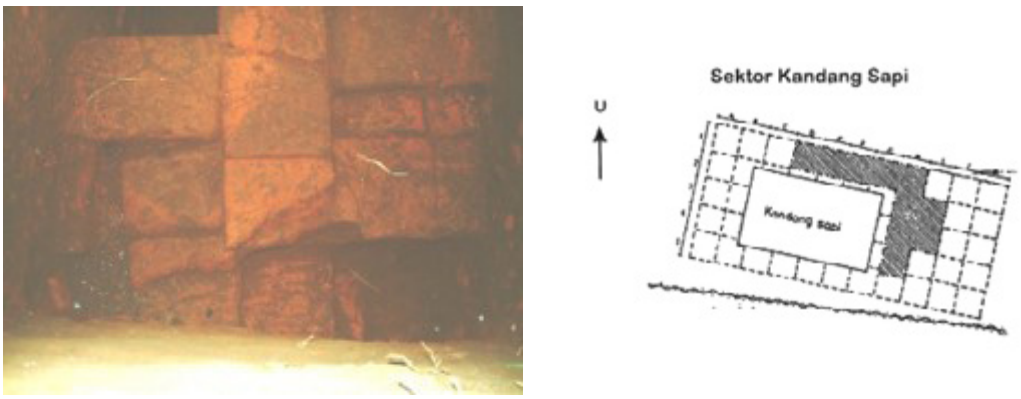

Figure 8. Brick structure (left) and floor plan (right) of interpreted temple near Klakah Lake. Source: Documentation of Balai Arkeologi Daerah Istimewa Yogyarkarta, 2012.

part of the temple foundation (Gunadi Kasnowihardjo 2012b: 145-162; see Figure 8).. Hindu-Buddhist culture was also characterized in the lake area by some Chinese coin findings, which Javanese people call *kepeng*. *Kepeng* was the Chinese currency in circulation as a medium of exchange both in China and across the Southeast Asia region. The distribution of *kepeng* is analogous to trade relations between Chinese peoples and other peoples in the region since the fifth century AD (Adi 1994: 173). Physically, *kepeng* have characteristics such as a round-shape with a rectangular hole in the middle. They are made of bronze, with one side bearing Chinese characters, usually consisting of four letters surrounding the rectangular hole, and read clockwise. Among the *kepeng* found in the lakes area is one from Segaran Lake, interpreted to be issued by the Empire of the Ming Dynasty, between AD 1368-1398 (*ibid*.).

Early Islamic culture

Islamic cultural remains found in the lakes region includes a cemetery and *punden* (ancestor worship location); the old grave is believed to be that of the ancestor of the local community (Gunadi Kasnowihardjo 2015), and follows Indonesian Muslim grave orientation of north to south, with a pair of headstones made of monoliths of unworked stone, but with no sepulcher at these early times. This type of tomb is different from the general portrayal of Islam in Java since the fifteenth century AD. The Ancestor Figure is believed by people in the lakes region to be a supernatural figure with magical powers. Folklore developed in several of the lake areas related to their ancestor was generally similar and suggests that the earliest inhabitants of the lakes region were immigrants coming from Madura Island to Java. They are understood to have brought their knowledge of stone axe-making technology. It is also believed that the old graves beginning in Islamic culture were still influenced by the previous cultures.

Ethnographic analogy

The lakes region is a land with considerable potential for humans, up to the present day. Ethnographic data in the lakes area suggest that it was continuously inhabited from early times to the present day (Gunadi Kasnowihardjo 2015). Ethnographic data found in this research area generally can be divided into two categories. One is related to physical activities such as some ritual ceremonies, including communal 'clearance village' rituals and individual rituals such as birth, marriage, death and other life-cycle ceremonies. 'Clearance village' is intangible culture, usually held after paddy harvest time (personal interview with H. Sholeh, seventy years old). The 'clearance village' ceremony is performed for three days and three nights, with the first day focused on preparing to slaughter three or four cows. On the second evening all the people attend to pray at the head of the village's house until midnight. On the third evening the event is enlivened with local theatre, orchestra and other local arts entertainments. In both the ceremonies that are communal and individual, the community will not leave, to provide better offerings to lakes, freshwater resources, as well as to *punden* (ancestor worship locations).

The second category is related to values and the philosophy of life, especially regarding environmental conservation, which involve the interests of all living things. An example of intangible data found in the communities in the lakes region is a phrase that was left by our ancestors who stated that: 'In 'tlethong' someday be turned into gold, the existing forest will be transformed into agricultural land (fields), while the fields you will turn into the forest'. This expression contains a very deep meaning and is a warning to us and future generations in managing natural resources and environment. How to translate this phrase depends on the present conditions, but the concern expressed by our ancestors has become a reality. The concept of value that some people in Ranu Gedang village found was as follows: 'Do not easily cut down the trees, our children and grandchildren will find it hard to find woods, if the forest is bare then the freshwater sources will die'. This concept of environmental values is now widely violated by our generation for the sake of a moment, without consideration for long-term woes. The wisdom

of indigenous ancestors, taught to the people who inhabited this lake area up to a few decades ago, is becoming obsolete. This fits with the statement of Soemarwoto (2005) that Indonesia has more than 500 lakes with a total area of over 5000 kilometers squared, or approximately 0.25% of Indonesia's land area, but the status of the condition of most of the lakes has lately been very poor, and the perceived benefit of the lakes is on the wane. This phenomenon is caused by pollution and environmental degradation of the lake waters, and very weak or almost non-existent inter-sector coordination in the management of the lakes.

Contribution of archaeological research to the public

A simple reconstruction of past life in the lakes region from the archaeology suggests that the lakes have the environmental potential to meet human needs. The ecosystem of lakes, mountains and forests will determine the future fate of the freshwater resources in the region. At Gedang and Bethok Lakes, lake water volume shrinkage has been significant. The advice and warnings of our ancestors, embodied in their concepts of value, are apparently no longer being paid attention to. Based on calculations using the Universal Soil Loss Equation (USLE), erosion rates on land around Bethok Lake in April 2011 had reached fifty tons/acre/year (Gunadi Kasnowihardjo 2011: 13). Of these, some cubic meters will enter the lake, so, sooner or later, Bethok Lake will experience drying-up or siltation. This is already evident in the dry season; most of the Bethok Lake basin can function as wet rice agricultural land, because open water remains only the middle of the lake, with a depth of only one to two meters. The volume of water in the rainy season is large enough that this reaches a depth of four to five meters.

The fairly high attrition rate in the Bethok Lake region is caused by environmental management of natural ecosystems. Regulations on the use of protected forest, production forest, and forest preservation and conservation should be highlighted, particularly with regard to negative impacts such as erosion, landslides, and the declining quality of freshwater resources. In addition to the local Bethok Lake ecosystems, the macro-ecosystem that includes the region of Mount Lamongan and its environment must be considered. Government regulations about logging policies also need to be evaluated. From observations noted during this research in Lumajang and Probolinggo Regencies, it seems that the protected forest management of the Lamongan Mountain area in the administrative district of Lumajang has led to better preservation than that of the Probolinggo Regency. Because of activities aimed at trying to maintain the existing ecosystems of the Mount Lamongan environment, such as Lamongan Conservation Run activities, it is not surprising that the water discharge of Klakah Lake is still up to 1.5 meters cubed/second, even though the dry season water level measured was around 0.2 meters cubed/second (Gunadi Kasnowihardjo 2007: 3).

The results of archaeological research can be used for public purposes, primarily related to the past reconstruction of local wisdom that is very useful for human life today and for future generations. However, in actualizing the results of archaeological research, archaeologists should collaborate with various disciplines and institutions (Tanudirjo 2011; see also Gunadi Kasnowihardjo 2007). The results of archaeological research can be developed in the four lake areas discussed above. Research in the Klakah Lake area in 2007 was constrained by the existence of residential house buildings and cow dung. The brick temple foundations and structure of the rectangular stone enclosure studied are estimated to need intervention, at some cost. We must release some buildings and land owned by local people. If this case can be resolved, then the Klakah Lake region could be developed with an integrated attraction focusing on cultural tourism and ecotourism.

One interesting case study in the Gedang Lake area studied in 2008 is the extinction of freshwater mussel species that were consumed by people living in the lake area. The causes of extinction of these species can be studied by biological and ecological disciplines, who could find a way to reintroduce or conserve

mussel species. The results in Segaran Lake, studied in 2009, are quite attractive for future development based on toponomy; the meaning of the word *krajan* is 'residence of a village official'. At Krajan hamlet some early settlement indicators were found and could be further investigated. The location of ancient settlements in the lake region can be referenced in future spatial planning around these and other lakes found in Lumajang and Probolinggo in particular, and in East Java in general.

The water volume shrinkage in Bethok Lake is an interesting phenomenon which could be studied by looking at past settlements and lake histories in the region. This case is an example of ecosystem damage caused by human activity no longer following local wisdom that teaches us how to manage the environment and maintain the ecosystem of the lake region.

These four examples could be developed in collaborative research, and I believe the results would be beneficial to human life, especially to the next generations (see Gunadi Kasnowihardjo 2015). In other words, efforts to restore the ecosystem of the lakes region today will result in the welfare of future generations.

Conclusion

The settlement patterns in the East Java lakes region show a difference to other lake regions in the area, which generally see houses built on lakeshores and around the lakes; in East Java dwelling houses were not near the lakes, but relatively near freshwater resources, on relatively flat land that could be used for farming. Ancient settlements in the region date from at least the Neolithic and continued in a sustainable way up through the Hindu-Buddhist period, the Islamic period, and to recent times (Gunadi Kasnowihardjo 2015).

One goal of this archaeological study was to reconstruct past lives and explore the values of local knowledge which has proven benefits for modern human life. The results of archaeological research are a form of national identity. We, as the modern generation, should be able to actualize and preserve some past life aspects in order to maintain the quality of life for the next generation. The results of archaeological research can be developed for pragmatic assessment, such as the suggestion for development of the Bethok Lake archaeological sites as an integrated tourist area that includes cultural and natural, agro- and culinary tourism. This type of development can be carried out through collaborative research, especially in cooperation with the provincial and/or district governments.

More important, the findings from such studies can be used to help restore the potential of the natural environment, reviving the values of local wisdom that have been abandoned. Both of these must be carried out simultaneously. *The Future is an Ancient Lake* is the title of a book edited by Caterina Batello (2004) that explains how local residents in the area of Lake Chad in Africa are able to preserve the natural environment and to maintain the values of the inherited wisdom of their ancestors, so that this generation will contribute something needed by the next generations.

The relevance of archaeology to contemporary concerns: the Department of Agriculture of the Philippines and ancient foodways

Michelle S. Eusebio

One of the ways to evaluate how archaeology can be relevant to contemporary concerns is through investigating the agencies that provide policies and programs for the benefit of people. This paper examines the policies, programs, and other documents of the Department of Agriculture of the Philippines. It discusses the important concerns of this agency, how far back in time it looks when making its policies, the time horizon being projected forward when policies are created, if this agency considers the sociocultural contexts of its subjects, for whom the policies are meant to be implemented, and how food is discussed in Southeast Asia archaeology. The paper ends with a few recommendations on what archaeologists and the Department of Agriculture can do to have their concerns met on a common ground, with beneficial outcomes for both, and for their subjects in the present and the future.

Introduction

One of the ways to evaluate how archaeology can be relevant to contemporary concerns is to investigate the agencies that provide policies and programs for the benefit of people. Archaeologists can investigate the relevance of archaeological research interests to contemporary concerns by looking at the policies and programs of government agencies. Since my research interest involves Neolithic-Metal Age foodways in Southeast Asia (Eusebio 2015), I investigated one of the Philippine government agencies concerned with food. It is the Department of Agriculture that formulates and implements policies related to food security and the sustainability of food production (Department of Agriculture 2012a). It is the main government agency accountable for promoting development and growth in agriculture and fisheries. It renders policies to guide public investments, support services needed for the profitability of agriculture-based endeavors, as well as aiding in spreading the benefits of development to the poor, especially those living in rural areas. Its mission is to increase the income of farmers and fisherfolk, in connection with the goal of the national government to lessen poverty, create opportunities, promote social justice and impartiality, and foster sustainable economic growth (*ibid.*).

The Department of Agriculture and Manufacturing was established as one of the first government agencies after Philippine independence was declared on June 12, 1898 (Department of Agriculture 2012b). Its official name underwent several changes until it finally became the Department of Agriculture in 1987 through Executive Order No. 116. The secretary during the writing and presentation of this paper was Proceso J. Alcala, who was appointed on June 30, 2010, and was one of the main authors of Republic Act 10068, or the Organic Agriculture Act of 2010 (Alcala 2009), which aimed to reduce rice shortages and importation of rice by increasing rice production in the Philippines, so that the country would be independent of rice imports by 2013. This involved the expansion of areas for rice production by including uplands, marshlands and unused farms. He initiated the framework of 'Agrikulturang Pinoy' (Filipino Agriculture) to guide policy implementation in 2011-2016 and after, where agriculture and fisheries supply food and raw materials for the Philippine economy (Department of Agriculture 2012b).

Although both Philippine archaeological research and the Department of Agriculture are concerned about food, little to no communication exists between them, based on my observations when I was a graduate student at University of the Philippines-Archaeological Studies Program. Works that endeavor to relate anthropology (Shore *et al.* 2011) and archaeology (Sabloff 2008) to policy-making suggest that

the Department of Agriculture and other agencies should incorporate anthropological insights from ethnographic works as well as long-term perspectives from archaeology and other sources of deep historical data in their policy-making and implementation. At the same time, archaeologists should be able to relate their research concerns to pressing concerns of the present (*ibid.*), such as those being tackled by the Department of Agriculture. Agencies and social scientists such as archaeologists should communicate with each other.

In this paper, I examine the policies, programs, and other documents of the Department of Agriculture of the Philippines. Although it was not feasible for me to go to its office in Manila to inquire about its policy making, its Website at <www.da.gov.ph> provides online links to its major policies and recommendations. Specifically, I examined the following policies, programs, and documents; hereafter they will be referred to by the acronyms listed in brackets below:

- Republic Act No. 8435 (RAN 8435): Agriculture and Fisheries Modernization Act (Angara 1997)
- Policy and implementation program on climate change (IPCC) (Department of Agriculture 2011)
- Republic Act No. 10068 (RAN 10068): An Act Providing For the Development And Promotion of Organic Agriculture in the Philippines and for other Purposes (Alcala 2009)
- The Philippine Fisheries Code of 1998 (PFC 1998) (Department of Agriculture 1998)
- Agri-Pinoy Rice Program (APRP) (Department of Agriculture 2012c)
- Agri-Pinoy Livestock Program (APLC) (Department of Agriculture 2012d)
- Sugarcane Industry Roadmap (2011-2016) (SIR) (Department of Agriculture 2012e)
- 2010 Year End Report (2010 YER) (Alcala 2010)
- 2011 Year End Report (2011 YER) (Alcala 2011)
- Food Staples Sufficiency Program (FSSP) (Department of Agriculture 2012f)

Based on these programs and policies, I address the following questions: What are the important concerns of a government agency, specifically the Department of Agriculture? How far back in time does an agency, specifically the Department of Agriculture, look when making its policies? What is the time horizon being projected forward when these policies are created? Does the Department of Agriculture consider the sociocultural contexts of its subjects, for whom the policies are supposed to be implemented? And how is food discussed in Southeast Asian archaeology, especially in prehistory? The first and last questions are addressed to be able to make connections between the Department of Agriculture and archaeology.

Pressing concerns

What are the important concerns of a government agency, specifically the Department of Agriculture? These concerns can be deduced by looking at its goals or objectives.

RAN8435 focuses on five major concerns: food security, poverty alleviation and social equity, income enhancement and profitability, especially for farmers and fisherfolk, global competitiveness, as well as sustainability (Angara 1997: 9). The IPCC focuses on actions needed for agriculture and fisheries to successfully adapt to future climate change (Department of Agriculture 2011: 6-7). RAN10068 (Alcala 2009) seeks to improve soil fertility, farm productivity, environmental conditions, the health of producers and consumers, and to promote the adoption of organic agriculture.

PFC 1998 (Department of Agriculture 1998: 1-2) aims to improve the management of fisheries and aquatic resources, the lives of municipal fisherfolk, aquacultural productivity, the efficiency of the use of offshore and deep-sea resources, as well as post-harvest technology. APRP is primarily 'concerned in rice farming and uplifting the lives of Filipino farmers' (Department of Agriculture 2012c: para. 7), while the APLC

focuses on disease control, conservation and improvement of genetic materials, the establishment of post-harvest facilities and alternative nutrition technologies, and the possible export opportunities of pork and chicken (Department of Agriculture 2012d: sec. 4). SIR is mainly concerned with the reduction of tariffs on imported sugar by 5% for the year 2015 and beyond (Department of Agriculture 2012e: para. 1). Moreover, the FSSP (Department of Agriculture 2012f: 3), under the Agrikulturang Pilipino (Agri-Pinoy) framework, sought to attain self-sufficiency in food staples to ensure food security by 2013, improving the lives or increasing the incomes of food producers, and to strengthen national resiliency in the production of staples against the impacts of climate change beyond 2013. The program covers rice, which is the most important staple food in the Philippines, and traditional staples in rural areas, such as white corn, the *saba* variety of banana, and root crops such as *kamoteng kahoy* (cassava) and *kamote* (sweet potato). These are also increasingly recognized as healthy staples in other parts of the country (Department of Agriculture 2012f).

In summary, the Department of Agriculture documents show a concern with self-sufficiency in food staples to ensure food security, improving the lives or increasing the incomes of food producers, resiliency of food production against impacts of climate change, sustainability in food production and use of food resources, as well as preservation of biodiversity, genetic materials, and the environment. Archaeological research on food (subsistence strategies, diet, and foodways) should be helpful in policy making and implementation related to the department's main concerns.

Looking back

How far back in time does an agency, specifically the Department of Agriculture, look when making its policies? This can be deduced by looking at the background data that this agency uses to make its policies. RAN 8435, IPCC, PFC 1998, FSSP, and the 2010 and 2011 YER documents provide hints on how the Department of Agriculture looks back in time in formulating its policies and programs.

In Section 42 of RAN 8435 on information and marketing, the National Information Network is obliged to provide background data related to agriculture and fisheries (Angara 1997: 16). These include supply and demand data, prices and price trends, product standards, a directory of cooperatives, traders, key market centers, processors and business institutions concerned with agriculture and fisheries at the provincial and municipal levels, research information and technology, international, regional and local market forecasts, as well as resource accounting data (*ibid*.). With the exception of the directory and forecasts, however, it is not clear either how far back in time (e.g. from one to ten years ago) or on what time scales (days, months, years, or decades) these data are supposed to be gathered and provided to policy makers and intended beneficiaries.

In the case of IPCC, Secretary Alcala (2011: 1) wrote a memorandum about institutionalizing the climate information system for agriculture and fisheries via the Unified and Enterprise Geospatial Information System (UEGIS) project into climate change vulnerability maps, as well as the generation and analysis of local weather data to serve as an early warning system, basis for planning of cropping and cultural management practices, and resource mobilization. The IPCC is not clear about the time-depth of the data to be gathered for the UEGIS. However, according to Honorio Cruz Flameño (2011: para. 4), the IT Officer of the Information Technology Center for Agriculture and Fisheries Department of Agriculture, the primary data come from surveys and actual field data collection. It seems that the data being gathered for the project are very recent. The project was established for better planning, decision-making, and service improvement of the Department of Agriculture.

The IPCC (Department of Agriculture 2011: 4) must have some basis for noting that El Niño and La Niña events occur about every two years, but the source was not cited, and the time-depth used in assessing

this cycle cannot be inferred from the document. The IPCC based their possible scenarios of impacts of climate change on cited sources that are global in scope (*ibid.*: 5, e.g. citing National Oceanic and Atmospheric Administration (NOAA 2007)), and it is not clear how these were directly applied to the Philippines. Further, several lines on climate impacts mention records on different timescales for the past century (e.g. Lehodey *et al.* 2006: 5012-5024). In effect, the time projection backwards used by the Department of Agriculture depends on the references they cite, and that these are international. It seems that they do not seek data from local agricultural and fisheries research and the development realm. For the PFC (Department of Agriculture 1998: 2), it is stated that a flexible policy must be adopted based on demographic trends for fish, but the document does not expound on the time-depth of these trends, nor what they mean by adaptable technology.

In the 2010 YER (Alcala 2010: 8), only the 2008 rice crisis is cited to justify goals for the following year (2011), and the aim to eliminate an over-dependence on rice imports in the following three years. On the issue of climate change, it is noted that the department must strengthen and modernize data collection to be able to track and conduct efficient surveys, since accurate statistical records are crucial in making and implementing programs (*ibid.*: 9). The report is not explicit on the time dimension of data collection. The 2011 YER (Alcala 2011: 1) only cites the long dry spell of 2010 to prove the resilience of the agriculture and fisheries sectors.

The FSSP (Department of Agriculture 2012f: 2) looked back forty years for their performance overview of rice production. This is the only policy that explicitly indicated how far back in time the department looks when formulating its policies and programs. The food crisis of 2008 also had a major role in the formulation of this program (*ibid.*: ii).

Looking forward

What is the time horizon being projected forward when these policies are created? This can be deduced by looking at the time frame considered when the policies and programs were created.

In RAN 8435 (Angara 1997: 1, 9-10, 14), there are occurrences of the words 'short-term', 'middle-term', and 'long-term'. For example, their principle on sustainable development states that '...the State should exert care and judicious use of the country's natural resources in order to attain long-term sustainability' (*ibid.*: 1). It is not clear how long in time the Department of Agriculture means by these terms, but at least the policymakers were thinking of three scales of time horizon. The definition of food security shows RAN 8435 to be future-oriented, where the policies should benefit the 'present and future generations of Filipinos' (*ibid.*: 4). Other acts also have a prevalence of the word 'long-term'. In RAN 10068 (Alcala 2009: 3), for example, among the goals of organic agriculture is long-term fertility of soils.

For the IPCC, the spatial impacts of climate change that are being predicted are not clear in terms of time dimension. As noted above, the Department of Agriculture (2011: 5) based its predictions on general sources, which are global in scope, and may not be applicable for local contexts in the Philippines.

The programs of Agri-Pinoy were designed for the year range of 2011-2016 (and beyond) and included the APRP (rice) and SIR (sugarcane) programs. For APRP, it was targeted that the Philippines would be able to produce its domestic requirements by 2013. After 2013, the aim is to strengthen resilience by the production of staple goods (Department of Agriculture 2012c: sec. 3). The same is the case with the FSSP, closely tied to APRP, which only uses the 'long-term' ('long-term poverty reduction', 'long-term solution'; Department of Agriculture 2012f: 7). The 2010 and 2011 YER reports look one year ahead only ('Moving Forward: Plans for 2011' and 'Looking Ahead to 2012' (Alcala 2011: 5, 8), since budget allocation on the national level is on a yearly basis.

Considering cultural context

Does the Department of Agriculture consider the sociocultural contexts of its subjects, for whom its policies are supposed to be implemented? This can be deduced by looking at the human, cultural, or social aspects of the policies, programs, and several documents.

In Administrative Order No. 23 signed by Secretary A.C. Yap in 2007, the definition of 'applied research' is interesting for its allusions to the inclusion of social sciences. Applied research is divided into pretechnology sciences and technology invention (Yap 2007: 1). The social sciences of anthropology and sociology are included in technology invention, along with agricultural chemistry, plant and animal breeding, horticulture, agronomy, veterinary medicine mechanics, irrigation methods, communications research, extension research, computer software development for the agriculture and fisheries, and farm management (*ibid*.). Thus, the Department of Agriculture seems to have a consideration of the sociocultural aspects of policy making. This is also shown in RAN 8435, IPCC, RAN 10068, and PFC.

In RAN 8435, equity for small farmers and fisherfolk is included in the objectives. The document defines 'socio-culturally sound' as 'the consideration of the social structure of the community such as leadership pattern, distribution of roles across gender and age groups, the diversity of religion and other spiritual beliefs, ethnicity and cultural diversity of the population' (Angara 1997: 8). It also has special concerns regarding indigenous groups. However, it seems that there is no consideration of culture or tradition in the objective of promoting the appreciation of science in agriculture and fisheries development. There is an emphasis on science only as it is important for national development and progress.

IPCC implies that poor farmers and fisherfolk need the assistance of the Department of Agriculture to be able to adapt to climate change (Department of Agriculture 2011: 6). It also emphasizes that the science and technology sectors are involved in initiating innovation for local communities to be able to mitigate and adapt to climate change (*ibid*.: 14). Further, it is noted that successful community stewardship needs 'top down' interventions, such as policy, funding, institution building, and technical support, and enforcement (*ibid*.: 18). From the anthropological perspective, top-down approaches dealing with research, formulation and the implementation of policies are not necessarily effective and beneficial for local people (e.g. Shore *et al*. 2011).

RAN 10068 recognized the central role of grassroot communities (farmers, indigenous people and other stakeholders) (Alcala 2009: 2). The PFC 1998 was formulated to protect the rights of fisherfolk in the use of the waters for fishing. It also indicated that social research must be conducted on fishing families to better understand their conditions and needs (Department of Agriculture 1998: 26). The 2010 YER is more focused on the administrative aspects of the Department of Agriculture; however, one of the plans mentioned highlights the capabilities of farmers and other food producers to choose and diversify their production systems. The department provides alternatives based on the research, development and extension programs, as well as respecting the rights of stakeholders to decide (Alcala 2010: 10).

The 2011 YER is centered on the beneficiaries, who are farmers and fisherfolk. The report starts by stating that the most significant achievement of the Department of Agriculture in 2011 was '...restoring the trust of the farmers and other agricultural stakeholders in the government' (Alcala 2011: 1). The report indicates that the secretary was able to know 'the ground situation' by visiting farmers and local people, people working for the Department of Agriculture, and local government officials. The 2011 annual report claims that the department serves the interests of farmers and develops community-based programs to address the poverty of fishing families and communities (*ibid*.: 2, 4, 6).

The farmers are the focus of the Food Staples Sufficiency Program (FSSP), as shown by its foreword and throughout the policy book. Aside from restoring the trust of farmers as a mission, the formulation of the program was based on '...direct interactions with farmers, program implementers, local officials, business, bankers, and other stakeholders' (Department of Agriculture 2012f: ii).

Food in Southeast Asian archaeology

How is food discussed in Southeast Asian archaeology? The discussion that follows here tends to be biased toward the Neolithic and Metal Age, as well as Island Southeast Asia, especially the Philippines and Borneo. The literature review is by no means comprehensive, but it gives a general impression of the state of things. This literature was examined regarding what issues scholars researching Southeast Asian archaeology associate with food. The majority of the literature examined discusses food in four ways.

First, food is discussed in terms of modes of subsistence in association with the environment. Authors mostly link subsistence with available food sources from the environment, and with type of environment. For instance, commonly-occurring subsistence strategies during the Neolithic are the shift from hunting and gathering to farming (food production and/or systematic collection), shellfish gathering, continued reliance on hunting-gathering, or maintained hunting and gathering combined with farming (e.g. Krigbaum 2003, 2005; Bacus 2004; Barker 2006), foraging while exchanging food with farmers (e.g. Mijares 2006), and fishing (e.g. Ono 2003; Campos 2009). Available resources mentioned are usually wild terrestrial animals, terrestrial bivalves (e.g. Krigbaum 2003, 2005; Piper *et al.* 2009a; Garong *et al.* 2009), as well as inshore and pelagic fishes (Ono 2003; Campos 2009). Hunting wild animals and gathering plant foods are usually associated with forest environments, while farming is usually associated with open environments. In addition, shellfish gathering is often associated with riverine environments, while fishing is usually associated with coastal environments, although fishing can also be done in riverine, lacustrine, and estuarine environments (e.g. Piper *et al.* 2012).

The location and topography of the involved site(s) are important in the consideration of the type of the environment and possible subsistence strategies involved. To say that people in small islands only focused their subsistence on terrestrial resources seems to be unreasonable (e.g. Szabó *et al.* 2003), as clarified by some findings (e.g. Campos 2009). Associating subsistence mainly with the availability of resources in the environment seems to be very cultural ecology orientated; however, Krigbaum (2003, 2005), for example, associated subsistence with anthropogenic impacts (e.g. habitat modification). In addition, the work of Valentine *et al.* (2008: 1464) linked subsistence with geographical identity through the concept of 'dietary catchment attributed to specific regions in a landscape.'

Second, food is implicated in the discussion of modes of subsistence in association with the dispersal of people during the mid-Holocene and/or Neolithic in Southeast Asia. One standard view puts a higher emphasis on terrestrial living, where the spread of Austronesian-speaking farmers from Taiwan in the north to the South and East is related to the spread of rice agriculture, animal domesticates, such as pigs, and other materials that belong to a Neolithic material culture package (e.g. Bellwood 2005, 2009, 2011a, 2011b; Bellwood *et al.* 2011). This view is also called the 'Out of Taiwan' hypothesis. It states that before 3000 BC proto-Austronesian-speaking agriculturists from China migrated to Taiwan, and *c.* 2200 BC Austronesian-speaking people migrated from Taiwan to island Southeast Asia. This hypothesis is part of a larger farming/language dispersal hypothesis (Bellwood 2005; Bellwood *et al.* 2011). The dispersal of Austronesian-speaking farmers from Taiwan to the rest of island Southeast Asia has been further supported by the oldest evidence of domestic pig in the Philippines (Piper *et al.* 2009b).

Debates about the links between the dispersal of agriculture and of language or people are ongoing. Contradicting Bellwood (2005, 2009), and referring to Paz (2002), Donohue and Denham (2010) note

that there is a lack of evidence for domesticated rice associated with food processing and consumption, and they do not link rice agriculture with language dispersal, but instead associate rice with pottery production. They also note that bananas, sugarcane, taro, greater yam and sago have separate domestication histories, and are not included with the Austronesian cultural package. Dewar (2003) suggests that environmental factors affected the movement of agriculture, and rice-based agriculture might have been adopted by hunter-gatherers already engaged in plant management (Barton 2009). Paz (2002) contradicts the notion that the region is a 'spread' zone for the dispersal of rice agriculture along with Austronesian-speaking farmers, based on the available archaeobotanical data. He suggests that it is a 'friction' zone instead, because cereal agriculture had difficulties spreading due to climatic conditions, while pottery spread faster. Terms related to indigenous rice were also used to assess the farming and language dispersal hypothesis.

Paz (*ibid*.), Fuller *et al.* (2007, 2010), as well as Chi and Hung (2010) argued for multiple and slow routes of rice agriculture spread, in contrast to the 'express train' or quick spread of agriculture in the region. Chi and Hung (2010) noted that there were periodic returns to non-agricultural subsistence emphasizing fishing and hunting. Rice agriculture only spread quickly once the agricultural system became established with transportable domesticated plants and animals. Fuller *et al.* (2007) note that the pre-domestication cultivation of wild rice implies that sedentary hunting and gathering preceded agriculture, in contrast to the notion that sedentism was driven by agriculture.

Still within this subsistence and movement discussion, alternative views put emphasis on maritime living. The most popular is the Nusantao Maritime Trade and Communication Network hypothesis developed by Solheim (1984-1985, 2000; Solheim *et al.* 2006). With 'maritime' in the title of the hypothesis, there is an explicit emphasis on the importance of the sea. Migrating people, called the Nusantao, whose lifestyles were mainly maritime-oriented, were also knowledgeable of terrestrial living. Whether they were Austronesian-speaking people or not was not an issue. Based on the distribution of cultural remains, their origin or homeland was suggested to be in island Southeast Asia, between eastern Mindanao Island and northeast Indonesia (*ibid*.). In contrast to the north-south movement of the proposed Austronesian-speaking farmers from Taiwan (Bellwood 2005; Bellwood *et al.* 2011), the Nusantao people moved from south to north, and reached South China, Japan and Korea (Solheim *et al.* 2006). The Nusantao culture is claimed to be older than the Austronesian of the Neolithic (*ibid*.; 7000 BP or *c*. 5000 BC in Solheim 2000). Proto-Austronesian language was used for barter or trade. The proposed maritime network was multidirectional with many nodes. Ethnographies of several coastal and sea-dwelling people in the areas were mentioned to support Solheim's arguments (Solheim *et al.* 2006). He noted that 'Austronesian' and 'Nusantao' are not the same, since the former is linguistic, and the latter is cultural. Solheim (2000) claimed that his model fit the archaeological and linguistic evidence better than the reconstruction by Bellwood (op. cit.). The lifeways of the Nusantao are said to have been developed at least 11,000 years ago in the coasts and seas of Southeast Asia (Solheim *et al.* 2006). Shell tools are said to be part of the Nusantao tool kit (Solheim 1984-1985), and pottery vessels suggest a maritime trading network in the region (Solheim 2000).

The movement of Austronesian-speaking farmers with a Neolithic material culture package, including fishhooks and shell beads (Bellwood 1997), was challenged by the works of O'Connor (2006) and Szabó and O'Connor (2004). Based on the results of excavations in East Timor, where drilled *Trichus niloticus* shell beads and fishhooks were recovered from pre-ceramic levels at Lene Hara and Matja Kuru 1 and 2 sites, O'Connor (2006: 76, citing Bellwood 1997, 2002) saw the standard Neolithic cultural package – of '...cereal crop cultivation and domestic animals (at least pig and dog)....., red-slipped pottery....polished stone and shell adzes, stone bark cloth beaters and net sinkers, a variety of shell artefacts including bracelets and drilled beads and single piece fish hooks' – as a chimera. The components of this cultural package are not necessarily found all together at other Neolithic sites in island Southeast Asia. This material

culture package is too fragmentary and diverse to be considered as a cultural entity, and suggesting there was one package hides the local diversity and the complexity of the Holocene record (O'Connor 2006). She offered an alternative, where the picture of migrating people is more complex than what the dominant theory offers, with two-way interactions between Southeast Asia and Melanesia during the Holocene (*ibid.*: 77). Equating the Neolithic period with agriculture, ceramics, and other components of the material culture package must be abandoned. Note that this does not entirely contradict the orthodox view; O'Connor (2006) suggested that Austronesian-speaking farmers may have encountered people who were already also using fishhooks and shell beads like them. Similar arguments are found in Szabó and O'Connor (2004). This work is partly based on Szabó's (2004) study of artifacts and production techniques from Neolithic sites in Palawan, Philippines. Bellwood *et al.* (2011) adjusted the make-up of the 'Neolithic cultural package' on the basis of such studies, and noted that it is not necessary that the components all arrive together with Austronesian-speaking peoples, and that Austronesian-speaking peoples were also involved with sea fishing, in accordance with the work of Sather (1995).

There are other integrated views on these matters of subsistence evidence as a marker for directionality of movement or interactions of people. For instance, Bulbeck (2008) provided an integrated view on the migration of Austronesian-speaking people, suggesting that although cereal (rice) agriculture was already well-established in Taiwan first, the southward spread of this food source and technology is associated with maritime foraging and trade. His work also agreed with Sather (1995). Bellwood *et al.* (2011) alluded to maritime aspects, such as fishing and seafaring from one island to another island; however, the heavy emphasis was always on agriculture that is part of terrestrial adaptation. Denham (2013) argued that there is no substantial evidence for Austronesian dispersal with cereal agriculture and animal husbandry from Taiwan to island Southeast Asia. Rather, early agriculture was based on noncereal plants that were cultivated and domesticated in island Southeast Asia and New Guinea, and early animal husbandry was based on animal domesticates that originated from mainland Asia (*ibid.*).

The third way that food is discussed in the literature reviewed is in debates on the foraging-farming transition, which is an offshoot of the first two discussions on subsistence related to paleoenvironments and the dispersal of people in Southeast Asia. There are three main issues discussed. The first is whether hunting and gathering was replaced or assimilated by farming upon the arrival of Austronesian-speaking farmers. Veth *et al.* (2005) and Pannell and O'Connor (2005) argued for the continuity of hunting and gathering (foraging) and/or a combination of foraging and farming, as well as continuity in cave site use, despite the adoption of farming in East Timor and the Aru Islands. Pannell and O'Connor (2010) noted that hunting-gathering is a risk-minimization subsistence strategy that is commonly utilized by swidden agriculturists in East Timor. In Sather's (1995) assessment, he suggested that a dichotomy between food production and foraging during early Austronesian colonization was unlikely, based on non-agricultural aspects of the model. He noted the historical roles of sea nomads in the region, such as the Moken, Orang Laut, and Sama Bajau, and suggested that, along with evidence from the foragers in Borneo, Austronesian settlements could have combined secondary foraging, hunting and fishing, and horticulture. The sea obviously shaped the history of the Austronesian-speaking world (*ibid.*). Generally, these authors contradict the replacement of hunting-gathering by farming and the assimilation of foragers by migrating farmers, by arguing for the continuity of foraging and the grafting of farming onto already existing subsistence strategies.

The second and third issues here are about rice. Was rice already cultivated by foragers in Southeast Asia before the Neolithic, or was rice agriculture brought by Austronesian-speaking farmers? Fuller (2011) and Fuller *et al.* (2010) noted that evidence for the spread of rice from mainland China to Taiwan and island Southeast Asia is scarce. This may indicate that the dispersal of Austronesian-associated Neolithic ceramics was accompanied by other forms of subsistence. Barton (2009) suggested that rice could have

already been adopted by people engaged with vegeculture before the arrival of Austronesian speaking peoples to the region. Barker (2006) and Barker *et al.* (2011) argued for a long process of experimentation and adaptation of rice by foragers even before the Neolithic, e.g. based on the early evidence of rice phytoliths from Loagan Bunut Lake, Sarawak, Malaysia (Hunt *et al.* 2006).

Barker *et al.* (2011) suggested that rice became a staple crop only after European colonization, but possibly had a social role from when it was first introduced. The third issue here is whether rice was a staple good from the beginning or was domesticated as a luxury good. Hayden (2003, 2011) argued for the latter and this is supported by Barton (2005, 2011) who noted that foragers rely more on sago, rather than rice.

Fourth and lastly, a minority view in the literature tackles issues beyond subsistence, such as preference, symbolic association, rituals, feasting, human-food entanglement, cuisine, and foodways. Campos (2009) noticed that the preference for the pelagic dolphinfish from the Neolithic in Batanes Islands, Philippines, is similar to the present-day preference, as are the processing techniques involved. Ono (2003) noted the preference for inshore coral fishes by the inhabitants of the Bukit Tengkorak site, Borneo (Malaysia), and that the abundance of fish remains compared to other faunal remains indicated the similarity of that site to sites in the west Pacific of the Lapita culture, and unlike other Neolithic sites in Southeast Asia; however, the geography, proximity of the site to other sites, or other cultural factors could not be clarified. The works of Cucchi *et al.* (2009) in insular Malaysia and Piper *et al.* (2009a) in the Philippines suggest that a dietary preference for wild pigs during the Neolithic could be due to the symbolic significance of domestic pigs, as is observed in the present-day inhabitants of the areas near their archaeological sites. Similarly to Campos (2009) on pelagic fishes, however, they are not definite about the symbolic associations of the domestic pig.

Hayden (2003, 2011) suggested the possibility that plants and animals were domesticated as luxury foods due to symbolic association for feasting purposes, based on what he observed in ethnography. The impetus to cultivate plants and maintain animals was the symbolic association of food items. For instance, the betel nut is not a main food item but functions as a medicine, in rituals, and in social transactions (e.g. Rooney 1993). It also has a lot of symbolic associations documented in folklore (e.g. Conklin 1958). Zumbroich (2008) noted that the practice of betel-nut chewing had emerging importance in Austronesian-speaking societies, as shown by evidence in the archaeological record, especially in burial contexts. De Vera (1990) and Duggan (2011) wrote about the ritual and symbolic associations of pigs and chickens, respectively. Junker (2001) and Junker and Niziolek (2010) wrote about ritual feasting in protohistoric Philippine societies. Using relational approaches in archaeology, Denham (2007; 2011) treated food production or agriculture as directed by contemporary practice including contingency and as a lived experience, by using the dwelling perspective (after Heidegger 1962). By using the concept of human-food entanglement, Barton and Denham (2011) suggested that if the small quantities of rice remains found in Neolithic sites in island Southeast Asia represent plant cultivation, then plant cultivation could represent the cultivation of social relationships between people.

Writings on cuisine that reference archaeology and history include those by Anderson (2007) on Malaysia, Fernandez (1986, 2003) on the Philippines, as well as Lerida and Garay (2010) specifically on Butuanon cuisine of the southern Philippines. Foodways are alluded to in the works of Anderson (2007) and Lape (2000, 2004, 2005) on the pre-colonial and Islamic period Banda Islands, Indonesia. The latter noted a change in foodways through a sharp drop in pig remains in the archaeological layers after Islamization.

Discussion

Generally, the policies and programs of the Department of Agriculture of the Philippines have an emphasis on sustainable development and food security. Their main concerns are self-sufficiency in food staples to ensure food security, improving the lives/increasing incomes of food producers, resiliency of food production against impacts of climate change, sustainability in food production and use of food resources, as well as preservation of biodiversity, genetic materials, and the environment. The department bases its policies on available background data; however, the time depths of these data are not indicated, except for the FSSP (forty years). It seems that the background data the department uses are mostly from the recent past, as shown by the UEGIS project. Also, its time projection backwards depends on the references cited (e.g. FAO 2006 and NOAA 2007), which are global in scope and not necessarily applicable to local contexts in the Philippines. The year-end reports only reflect one or two years backwards in time.

The Department of Agriculture is future oriented, as shown by the prevalence of the words 'short-term', 'middle-term', and 'long-term', as well as the beneficiaries being the present and future generations. The programs are only designed in the short term, however, although they should extend beyond the time frame indicated (2011-2016 and beyond). This could be due to the fact that the term of office of a departmental secretary depends on the president of the country, who only has six years in one term of office.

It is written in the policies that the sociocultural contexts of the intended beneficiaries should be considered and incorporated; however, this is masked by the emphasis on science as a key to development and progress, top-down approaches in policy making and implementation, and (maybe) the actual practice of officials and employees in the department. The FSSP is an exception due to its emphasis on farmers as central to policy making. It also indicates that the policy was formulated with direct interaction with farmers. As indicated in YER 2011, the approach used was 'on the ground' instead of the usual top-down approaches. It seems that the approaches of the department changed, coinciding with the change of administration in 2010. Note that the FSSP booklet was only released in June 2012.

In practice, the Department of Agriculture of the Philippines should consider not only the anthropological or sociocultural perspectives in their policy making and implementation but also long-term perspectives from history and archaeology. Their background data need time-depth beyond years or decades For example, in terms of meteorological and climatic data, there is some archaeological research on ancient El Niño and related changes in the country (e.g. Bird *et al.* 2007; Wurster *et al.* 2010), there are references for the Spanish colonial period (e.g. Vaquero *et al.* 2005), and for a recent decades (e.g. Yumul *et al.* 2010). Thus, looking backwards can be done as far as the Spanish colonial period with the help of meteorological data, and possibly beyond using archaeological and paleoenvironmental studies, as has been done in other parts of the world (e.g. Beresford-Jones *et al.* 2009; Sandweiss *et al.* 2009). Discussions of food in Southeast Asian archaeology in terms of modes of subsistence in association with the environment and dispersal of people during the mid-Holocene and/or Neolithic in Southeast Asia can also provide long-term perspectives for their policy making and implementation

It is interesting that 'precision agriculture' as defined in IPCC (Department of Agriculture 2011: 19) involves taking account of 'weather predictions, planting design that considers sun and wind exposures, varieties highly suited to the soil and weather patterns, and the delivery of water and other inputs at the right time and at the right amounts' into considering planting dates. It is known that farmers who still practice traditional ways of farming are knowledgeable of weather and climactic patterns. To be able to be culturally context specific and more 'precise', insights from ethnographic research on traditional rice farming as well as past agricultural and horticultural systems must be incorporated in policy making. The discussions of food in Southeast Asian archaeology in terms of debates on the

foraging-farming transitions and issues beyond subsistence (such as preference, symbolic associations, traditions, and cuisine) can also provide insights in considering sociocultural contexts for policy making and implementation from a diachronic perspective

The Department of Agriculture should update its facts based on recent findings in Philippine and Southeast Asian archaeology. For example, in the article written on November 30, 2011 about the Department of Agriculture allocating thirty million pesos (1 USD = 42-43 Philippine pesos at the time) to restore the Ifugao rice terraces in northern Luzon, the antiquity of the rice terraces is still stated to be 2000 years old (Department of Agriculture Information Service 2011) despite the fact that this has been disputed in contemporary archaeological research (Acabado 2009, 2010). The archaeology of the Ifugao rice terraces supports a revisionist short history, in this case stating that the terraces were constructed only 205-735 years ago based on radiocarbon dates from house platforms found in a previous excavation (Maher 1973: 52-55, as cited in Acabado 2009), folklore, and the migration of people to Cordillera due to the Spanish pressure in the lowlands (Acabado 2009). This is opposed to the suggested 2000 year history of these field systems (Barton 1919 and Beyer 1955, as cited in Acabado 2009). The terrace system in the Bocos locality expanded in 302 years between AD 1486-1788 from the valley floor to the mountain top (Acabado 2009). The Department of Agriculture had, however, incorporated a heritage aspect by procuring heirloom or upland rice varieties to revive and sustain these. It was noted that the heirloom rice varieties are more expensive, but more profitable, than the more common lowland rice despite their lower yield (Department of Agriculture Information Service 2011). The ongoing Ifugao Archaeological Project (Acabado 2012) aims to not only provide insights into the terrace-building tradition of the Cordillera region in northern Luzon, but also to contribute to developing sustainable conservation plans for the rice terraces. Perhaps part of the financial allocation for the restoration of the Ifugao rice terraces should support this kind of archaeological research.

In developing and implementing programs to conserve and use the genetics of native or endemic animals as part of the livestock program at the Department of Agriculture, the department should update itself on the ongoing genetic research in the Philippines and Southeast Asia on ancient and modern domestic animals and plants (e.g. pigs in the works of Larson *et al.* 2007; Herrera *et al.* 2009; Herrera 2010; rice in Fuller *et al.* 2010).

Lastly, in their research and development, they should include and support anthropological and archaeological research on food production, procurement, and processing. The flow of knowledge should be not only one way from the Department of Agriculture to the intended beneficiaries through its extension programs. It should be two ways, where the past and traditional practices of farmers and fishers also inform and aid the Department of Agriculture in formulating its policies through research and development.

On the side of archaeologists

Since the Department of Agriculture and Philippine archaeology have the same concerns about food, the Department of Agriculture is a potential source for research support. However, archaeologists in the Philippines need to reach out to the department by making their research relevant to the main goals of the department, which are sustainable agriculture and fisheries as well as food security. As noted above, the majority of literature in island Southeast Asian archaeology treats food in terms of modes of subsistence in association with the environment and the dispersal of people, and in terms of foraging-farming transitions. The minority tackles issues beyond subsistence, such as preference, symbolic association, rituals, feasting, human-food entanglement, cuisine, and foodways. To illustrate how archaeology can engage more directly, insights that can be gathered from research on the phylogeny of endemic pigs based on ancient and modern DNA (e.g. Larson *et al.* 2007; Herrera *et al.* 2009; Herrera 2010) could be helpful in the preservation of biodiversity, genetic materials, and the environment,

which is a special concern of RAN 8435. In relation to early fishing also, research could go beyond issues like the antiquity of fishing implements (e.g. O'Connor and Veth 2004), and whether or not they are components of the Neolithic material cultural package (e.g. O'Connor 2006; Szabó and O'Connor 2004). The news on 7 February 2010 of the Department of Agriculture endorsing the use of circle hooks in tuna fishing (Department of Agriculture Press Office 2010) provides ideas on how research on early fishing can be relevant to contemporary concerns in the Philippines. Circle hooks are preferred because they are safer than traditional J-shaped hooks for dolphins and turtles, which cause suffocation and internal bleeding of these animals when swallowed (*ibid*.). Knowing that shellfish hooks were J-shaped in the archaeological past (O'Connor and Veth 2004), archaeologists can dovetail their research with the human impacts on fish and other sea animals. Knowledge generated from research can inform policy making related to marine resource exploitation.

Research on foraging-farming transitions and early plant cultivation (vegeculture and arboriculture) in Southeast Asia and the Pacific can inform us about risk-minimization strategies and environmental stewardship in the past that we can adopt today, ensuring sustainable production, resiliency against climate change, and food security. Research on sago, taro, and yam can inform the Department of Agriculture about their long-term histories as reliable crops, which are less risky than rice, and help in their inclusion as traditional staples in the FSSP (Department of Agriculture 2012f). Ironically, they are not included, while crops from the Americas (corn, cassava and sweet potato) are.

Perhaps people outside of the research community can relate more to other food-related issues beyond subsistence, such as preference, symbolic association, rituals, feasting, human-food entanglements, cuisine, and foodways. Atalay and Hastorf (2006: 283) defined foodways as 'production and procurement (subsistence strategies), processing, cooking, presentation, and eating' of food. Based on the wealth of the archaeological record in Southeast Asia in the Neolithic and Metal Age, we can reconstruct parts of ancient foodways. Production (agriculture, horticulture, animal husbandry) and procurement (hunting-gathering/foraging) are already commonly tackled as regards past subsistence strategies (e.g. Paz 2002; Bellwood 2005; Piper *et al*. 2009a; Fuller *et al*. 2010). Some research tackles food processing, such as butchering, cutting and smashing (e.g. Paz 2001; Piper *et al*. 2009a) and eating or consumption, based on diet studies (e.g. Krigbaum 2003, 2005). The material culture of the Neolithic and Metal Age guarantees that a whole picture of foodways could be completed through other ways of processing food items, as well as cooking and presenting them.

Conclusion

Reconstructing ancient foodways in Southeast Asia can provide long-term perspectives that can inform agencies concerned with food, such as the Department of Agriculture. These long-term perspectives can not only give agencies a longer window of time as a historical basis for their policy and program formulation but can also give a longer and clearer time forward to project the outcomes of their policies and programs. By extending from subsistence to foodways, archaeological research can connect to the main concerns of the department and other food-concerned agencies, as well as to the food-related concerns of people outside the academic community.

The challenge at both sides of archaeological research and the Department of Agriculture in the Philippines is making their research agendas relevant to the contemporary concerns of people. I agree with Honeychurch (2010: 405), who argued that 'archaeologists have a responsibility to apply their research and ask salient questions of narrowly conceived agendas for development' and that 'archaeology and archaeologists can effectively raise an authoritative voice, rooted in the past, to question simplistic and narrowly conceived frameworks for policy making.' (*ibid*.: 407). However, archaeologists should be aware of the contemporary concerns of agencies that formulate policies and programs in order to be

able to extend their research beyond addressing the usual big questions in archaeology. What I present here is only an example of an attempt to assess how the agendas of agencies and archaeological research can meet.

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Toward an understanding of cultural heritage and sustainable management: a case study from Phrae Province, Thailand

Mizuho Ikeda

Cultural heritage management is a co8mplicated field of disciplines and requires several different approaches, with what defines cultural heritage varying in each country, region and community. It is necessary to grasp what cultural heritage means in the society concerned. A better understanding of the stakeholders and social conditions of cultural heritage are essential factors for successful management. In this paper, cultural heritage is discussed from different perspectives. The city of Phrae in northern Thailand is introduced as a case study, and the relationship between cultural heritage and administrative authorities, the local community, and archaeologists involved in projects in the area is examined in order to facilitate comprehensive understanding of cultural heritage.

Introduction

Thailand is one of the most popular tourist destinations in the world (WTO 2019: 9). The promotion of tourism expands employment, activates local economies, and provides an opportunity for people to reconsider local tradition and history through the fact that tourists come to see their cultural heritage (Wannalert 2004). While there are positive aspects, tourism promotion can also create a negative impact on the management of cultural heritage, such as damage of cultural landscapes, the transformation of culture (*ibid*.; Charoenwomgsa 2004; Hitchcock *et al*. 2010), a lack of a sense of ownership (Lertcharnrit 2010), limited public involvement, and a decline in the quality of research as an increasing number of salvage excavations take place (Shoocongdej 2011).

Cultural heritage management or Cultural Resources Management (CRM) is practiced all over the world and is a complex field of disciplines, and requires several different approaches, with what defines cultural heritage varying in each country, region and community. A good understanding of the stakeholders and the social conditions of cultural heritage in each area are essential factors for successful management. In this paper, I will discuss the meaning and the management of cultural heritage for the local community, through the analysis of various viewpoints using a case study from Phrae province, northern Thailand.

Research objectives and methods

The main focus of this study is to promote the management of cultural heritage by local communities. Most of the heritage is neither monumental nor 'outstanding'. In the case of intangible heritage, most is embedded in its context, so that its value tends not to be noticed, and it is necessary to identify values that can meet the needs of the contemporary society. Moreover, certain academic value can be added through research, and then cultural heritage can become a useful resource for local communities.

To investigate the meaning and the value of cultural heritage, research interviews were carried out with a variety of people, such as local communities, district and provincial officers, schoolteachers and students, and professionals involved in heritage projects in Phrae. In the case of the local communities, a workshop was organized to explore interview data in depth. Also, observation of classes in school was conducted to survey how knowledge of cultural heritage was taught in a classroom environment.

Overview of study area

Phrae is located in the narrow basin of northern Thailand (Figure 1), surrounded by mountain ranges of 1000-1650 meters in altitude. The Yom River passes across the province to connect to the northern

cities and flows into the central cities in Thailand (Phrae Provincial Administrative Organization 2007: 1-2). It is located approximately 200 kilometers southeast of Chiang Mai, the second biggest city in Thailand. The population is around 450,000-500,000 and has tended to gradually decrease every year (Phrae Provincial National Statistical Office 2013). Because the province is situated off the main railway and motorway, it still keeps a somewhat traditional way of lifestyle.

Although traces of human inhabitation in Phrae seem to appear at approximately 4000 BCE, with finds of stone axes and stone tools from cave sites beside the river in the southern part of province (Phrae Provincial Administrative Organization 2007: 6), the main history of Phrae starts from the historic period of the establishment of the town (Figure 2). Through patching together fragmentary information with descriptions from the Chiang Mai Chronicle (Wyatt and Wichienkeeo 1998), it can be proposed that Phrae established itself as a city-state around the eleventh century CE and maintained independence from the twelfth to early fourteenth centuries. This corresponds to an archaeological interpretation that the city wall of Muang Phrae was built around the eleventh century CE (Tunprawat 2009: 186). The main resource for local history is temple chronicles, including the *Phrathat Cho Hae*, *Phrathat Doi Pu Phu Taep*, *Muang Long* and *Laem Li* chronicles, which focus on a holy relic deposited in the temple (Ongsakul 2005: 43-45). From the fourteenth century CE, Phrae gradually lost its power as a city-state, coming under the control of Sukhothai and Lan Na's Phaya Khamfu and King Tilokarat. In 1443 Phrae's Thao Maenkhum pledged his allegiance to Lan Na, resulting in the loss of the city-state's independence (*ibid.*: 48). The Wat Ban Sanuk stone inscription found in Wang Chin district is another important historical resource. The ancient site of Trok Salop is considered to be located in the center of the town, where the Huay Salok and Yom rivers are located. An inscription was found in the premises of Wat Ban Sanuk School in 1954. It was written in Sukhothai script, and mentioned construction of a stupa, and that its donation was made by a low-ranking noble. Although the inscription was dated to 1339 CE by Griswold and Prasert na Nagara (1979), Penth (1996) proposed the much earlier date of 1219 (but see Lorillard 2009: 46).

Besides sites, the specialty of the province is indigo dying and wooden products, and every Friday civil service and school children are recommended to wear indigo cloths to support these heritage products. At a local level, oral tradition is a common way to learn history. Ton Phung (Figure 3) and Wiang Taep

Figure 1. Northern Thailand, Phrae province. Map: M. Ikeda.

Figure 2. Muang Phrae, Muang Phrae district. Photo: MOAC Project.

Figure 3. Ton Phung. Photo: MOAC Project.

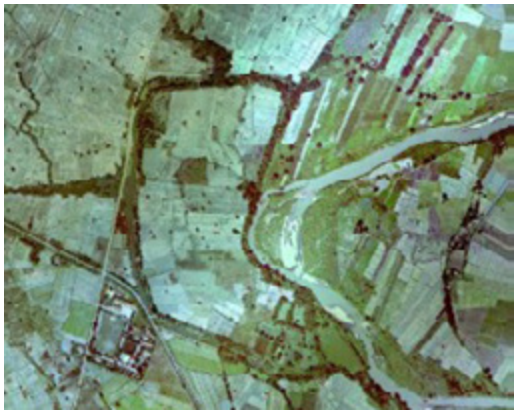

Figure 4. Wiang Taep. Photo: MOAC Project.

(Figure 4) in Song District are a good example of how lore and superstitious beliefs may be associated with archaeological sites. Ton Phung is a moated enclosure site with earthen walls and moats, and nearby Wiang Taep, located on the western bank of the Yom River, has a single earthen wall and moat. Both sites are believed to be residences of Prince Phra Lo and his lovers Phra Puen and Phra Phaeng, who are the main figures of the 'Story of Phra Lo', widely known in the northern region as a tale of tragic love. Both sites have been registered as monuments by the FAD, but because the land belongs to a private owner, the sites are heavily used for cultivation and fish farming. Although the sites await intensive research, the pottery found around the area (kept in the museum of Wat Phra That Phra Lo) shows characteristics of fourteenth to sixteenth centuries CE types. It is uncertain how far the Story of Phra Lo reflects actual history, but the connection between the story and the site enhances the sense of belonging to the land and interest in local history.

Concept of cultural heritage for local communities

The definition of cultural heritage is briefly explained by the International Council on Monuments and Sites (ICOMOS 2002: 21) as an expression of the ways of living developed by a community and passed on from generation to generation, including customs, practices, places, objects, artistic expression and values. It includes both tangible and intangible heritage. Because the concept is broad, it is important to identify what exactly cultural heritage means for the local community. To do so, I organized a workshop in cooperation with a local heritage interest group named Luk Lan Muang Phrae [children and grandchildren of Phrae] in 2012; the total participants were seven, consisting of five males and two females. Their professions varied from teacher to freelance business. First, the participants were asked to present their opinions about cultural heritage and then to classify the discussed opinions into several small categories. The discussion focused on cultural heritage (Table 1).

The results showed that intangible heritage – such as food, clothes, ceremonies and language – was mainly mentioned, while tangible heritage placed in the arts category included only temples, traditional teak houses, wood carving and silver accessories. Archaeological heritage was not referred to at all. This is because archaeological heritage in general is not recognized as part of local heritage, and therefore the maintenance of archaeological heritage tends to be regarded as a duty of the province and government. However, this does not mean that the community pays no attention to the archaeological heritage. They

Table 1. Examples of how the participants responded when asked 'What is cultural heritage?'

Type of cultural heritage	**Example**
Food	*Kanom dian* (sweet made from coconut milk), *khao keap* (rice cracker), *kanom chin nam sai* (noodle), *kanom krua* (sweet), *sarng wan* (warm salad), herb cooking
Arts	Old temple and temple design, traditional teak house, wood carving, silver crafts, *thung* (paper and metal craft), indigo dying, weaving and weaving design
Beliefs	・You shouldn't have any ceremony on the second and twelfth days of the moon calendar. ・Don't cut hair on Wednesday, and don't wash hair on Thursday. ・Don't bury the well and don't close the well. ・When a lizard makes noise in the house, it is a bad sign. ・Red *thung* is a sign of the dead. ・When you see something abnormal, you have to bring it to a temple.
Others	Thai language, Phrae local dialect, herbal medicine, religious ceremony and activity, folk story, Buddhism, *pi* (spirits)

recognize the heritage as an extension of beliefs and customs. For instance, a small shrine for spirits and folk stories associated with an archaeological site has been commonly observed. Some local residents are afraid to get close to the site because of their beliefs.

The second discussion (Table 2) examined the problem of the conservation of cultural heritage in Phrae. In order to analyze the issue in depth, the discussion focused on three topics, which were the tendency of society, education and family. These topics repeatedly appeared in the conversation during the workshop. In these topics, what I would like to draw attention to here is family issues. Because most heritage in Phrae is intangible, family plays an important role in transmitting knowledge of foods, designs, beliefs and customs. Local society has changed, dramatically affecting people's lifestyles and the ways of family. The issue affects not only the younger generation but the entire society.

The final discussion was about possible solutions of conservation of cultural heritage (Table 3). The answers corresponded to the second discussion. Throughout the activity, participants considered the connection between cultural heritage and people as important, in other words, how people can be involved with and connect to cultural heritage. Moreover, the role of education was also emphasized for heritage conservation. Education is certainly an important issue, but because two of the participants were teachers, it was normal for them to point out educational issues. Education will be examined further below.

Table 2. Answers to 'What is the problem for the conservation of cultural heritage in Phrae?'

Problem	**Example**
Tendency of society	Consumerism, materialistic culture, convenience
Education	Limited teaching ability, poor quality of textbooks, too much time spent in exam prep for both teachers and students, teachers not interested in teaching cultural heritage, problem of university curriculum
Family	Parents are too busy and cannot spend much time with family; family does not spend time together, young people forget how to speak Phrae local dialect and how to wear traditional clothes; decline in the value of cultural heritage in the family; young people do not consider the importance of cultural heritage; young people are exposed to too much media.

Table 3. Possible solutions, as discussed by LLMP members

Solution	Plan for activity
Improve the value of cultural heritage	・Encourage discussion among the community. ・Set up a Website or Facebook page to diffuse information on cultural heritage. ・Organize a fun and enjoyable cultural event. ・Create a computer game with the theme of cultural heritage. ・Find a better market where one can sell local products at a good price.
Improve the quality of education	・Enrich the content of university curriculum. ・Increase wages of teacher to prevent part-time work. ・Provide an informal workshop regularly for teachers to brush up their knowledge and skills. ・Use the 'Teacher channel' on ETV. ・Create a textbook/teaching materials for a class. ・Invite a famous person to talk about cultural heritage. ・Introduce a teacher who organizes a good cultural heritage class on local TV, and share their knowledge and skills. ・Invite people who are involved in conservation of cultural heritage to share their work experience. ・Explain the importance of cultural heritage study to the Ministry of Education, Department of Education, and schools, and increase the opportunity to study.
Raise awareness of the importance of cultural heritage in the family	・Have homework for students in regard to cultural heritage and ask for comments from parents. ・Organize a traditional clothes fashion show and encourage families to join in. ・Invite a famous or successful person of Phrae to speak in local dialect in a lecture, to decrease the bias of young people against it. ・Encourage families to join a cultural event and begin a conversation about cultural heritage. ・Let students perform historical theater. ・Organize a picture, documentary and essay contest on the lifestyle of Phrae. ・Organize a traditional song contest for kids. ・Ask parents or elders to record a program on a traditional ceremony to show on TV, and watch the video together with family.

Local communities and the management of cultural heritage

At a provincial level, there are several different institutions in charge of management of cultural heritage. The Fine Arts Department (FAD) is responsible for the protection of all archaeological monuments and remains in Thailand, but cultural landscapes are under the jurisdiction of the Office of Natural Resources and Environment Policy and Planning. The Office of the National Culture Commission is in charge of cultural plans and policies mainly focused on intangible heritage and organizes cultural exhibitions and activities. Local communities have more opportunity to know this institution than the others. There are several other institutions involved with culture indirectly, such as the Ministry of Education and Ministry of Interior. The structure of government institutions is quite complicated in terms of jurisdiction, making it difficult for both institutions and the local communities to cooperate with each other, but the field of cultural heritage requires holistic approaches. The following event that occurred in Phrae provides a good example.

In 2003, archaeologists from the regional FAD office excavated the city wall in order to study its construction technique (Tunprawat 2009: 187). It was believed by the local community that the city wall was a sacred representation of a great guardian spirit, and they built small shrines and respected the wall (Wanlipodom and Songsiri 2008: 175). For the local communities, the destruction of the wall invited bad fortune and evil spirits. The excavation was carried out without notification to the

local communities beforehand, and they protested the excavation, coming together and organizing awareness-raising activities about the value of the city wall. As a part of these activities, a City Wall Blessing Ceremony to get rid of evil spirits and invite good fortune was revived for the first time in almost 100 years (Tunprawat 2009: 187).

After this incident, LLMP became actively involved in conservation of cultural heritage in Phrae. Since 2004, LLMP has organized collaborative work with several provincial organizations and the Regional Center for Archaeology and Fine Arts of the Southeast Asian Ministers of Education Organization (SPAFA). According to Tunprawat (2009: 188), who has worked closely with LLMP from the beginning, their initial focus was on intangible heritage and awareness, but not physical heritage. They believed that successful heritage conservation could be achieved when people were made aware of the significance of cultural heritage, and that physical heritage conservation should only be implemented after successful dialogue with the community. However, from time to time, they faced the problem of management policy both within and outside of the group, and their activity stagnated. Later, LLMP reorganized, and changed into a loose coalition of groups which share different interests regarding cultural heritage. They gradually started getting more involved with conservation of physical heritage from around 2006, while continuing the dialogue between local residents.

Cultural heritage and school education

Thai education has undergone drastic changes and reformation. Today, Thai education faces the task of raising Thai identity by use of local culture and Thai wisdom in order to achieve a sustainable society, while developing human resources who can play an active role in global society (Ministry of Education, Thailand 2008). In the framework of Thai education, local culture can be taught in the local curriculum, which was a newly introduced subject after enforcement of the National Education Act 1999. The main reason for the introduction of the local curriculum was to deal with demand from educational institutions and local needs, because the conventional curriculum drawn up by the central government could not adapt or respond to the change of time (Hirata 2003: 6). In this curriculum, it is possible to teach local history and culture. The definition of Thai wisdom – called 'local wisdom' or 'local knowledge' – specifies nine categories (Samnakngaan khanakamakaan kaansukusaa haeng chaat 2003: 16-17): 1. agriculture, 2. local industry and handicraft, 3. traditional medicine, 4. environment and natural resource management, 5. business and regional capacity and funds to operate it, 6. art (painting, music, dance, sculpture, and folk art), 7. language and literature, 8. philosophy, religion, tradition, and 9. food and traditional cuisine.

The structure of education and Social Studies

In the Thai education system, the term required for graduation is six years at primary level, six years at secondary level and four years at university level. The period of compulsory education principally spans nine years from ages six to fifteen. According to statistical data from UNESCO (2012), the percentage of students who went on to higher education was 51.4%. Each school is authorized to develop a school curriculum based on the Basic Education Core Curriculum published by the Ministry of Education, Thailand (2008), but with textbooks published privately and selected by the school depending on their curriculum.

Social Studies is one of the subjects that deals with 'culture' and 'Thai knowledge' in the curriculum, along with Languages (Thai and foreign languages), Arts, and Physical Education. Social Studies consist of five areas of study: religion (morality and ethics), civics, economics, history and geography (Table 4). Learning time for history in primary education is assigned 40 hours per year, and the other four areas of study are provided eighty hours a year. In the case of lower secondary education, the time allotment

Table 4. Learning time (in hours)

Learning areas	Time allotment									
	Primary Education						Lower Secondary			Upper Secondary
	Gr 1	Gr 2	Gr 3	Gr 4	Gr 5	Gr 6	Gr 7	Gr 8	Gr 9	Grs 10-12
Social Studies	120	120	120	120	120	120	160	160	160	320
History	40	40	40	40	40	40	40	40	40	80
Religion, Civics, Economics, Geography	80	80	80	80	80	80	120	120	120	240

Extracts from Basic Education Core Curriculum 2008 (Ministry of Education, Thailand 2008), modified by Mizuho Ikeda

for history is forty hours per year and the other four areas are 120 hours per year. In upper secondary education history is taught for eighty hours within three years, and the other four areas have 240 hours allocated in three years. In other words, the hours difference between history and the other four areas is from ten to twenty hours a year. The abundance of learning time for history becomes more apparent in comparison with other main subjects.

Taking lower secondary education as an example, Thai, Math and Science are allocated 120 hours per year while Social Studies is taught 160 hours per year, including forty hours for history. In the curriculum, Thai history is a compulsory subject, and the content mainly consists of: 'before Sukhothai period' (thirteenth century and earlier), 'Sukhothai period' (1238-1583 CE), 'Ayutthaya period' (1351–1767 CE), 'Thonburi period' (1768-1782 CE) and Rattanakosin (1782 CE to present). Apart from Thai history, Southeast Asian history, world history and regional history are also taught, though the proportion of learning time is extremely small compared to Thai history. Moreover, Southeast Asia history and World history are not independent subjects in lower secondary education, which are taught in the context of Thai history. When it comes to upper secondary education, Southeast Asian history and World history (included in ASEAN Studies) are set as an independent subject, but usually taught for only one year or as an elective subject. Regional history is also an elective subject. (The above is based on data collected from: Ban Raow, Muangkhai Pittayakom, Rongkwarn Anuson, Song Pittayacom, Sungmen Chanupatham, Tinopat Vittaya, Vilaikiat Aupatham, and Wangchin Vittaya schools.)

Table 5 summarizes the topics related with 'culture' and 'wisdom' extracted from the Basic Education Core Curriculum (Ministry of Education, Thailand 2008). These topics are closely related to religion, civics and history. Religion is one of the important components in teaching Thai culture and identity. The students are encouraged to have practical experience of conservation and dissemination of culture.

The purpose of learning about other cultures is more to improve the understanding of Thai culture by comparison with others, rather than mutual understanding. History also plays a significant role; the students start learning Sukhothai, Ayutthaya, Thonburi and Rattanakosin cultures from grades four to nine, then in grades ten to twelve they analyze the factors affecting the creation of Thai culture and present-day society. Through the process, the learner understands what Thai culture is, with other cultures being disregarded or taught in relation to Thai culture.

Generally speaking, the local curriculum seems to be happily accepted where the school has authority to develop its own curriculum, but this does not mean that individual teachers have the ability or motivation to develop the curriculum themselves. In reality, the Basic Education Core Curriculum places pressure on local curricula: overemphasis on Mathematics and Science, too many subjects to teach, frequent change of policies, curriculum and personnel by the Ministry of Education, and a lack of teachers who can teach cultural heritage were also pointed out as issues by some teachers. Teaching

Table 5. Learning content associated with culture/wisdom

Level		Religion	Civics	History
Primary Education	Gr 1			
	Gr 2			Cite examples of culture, tradition, Thai wisdom that should be preserved
	Gr 3	Explain importance of Buddhism or of students' own religions as a significant foundation of Thai culture	・Summarize benefits of and observe family, local traditions, culture ・Tell their own way of life and that of others in diverse cultures	Summarize important characteristics of customs, traditions, culture of the community
	Gr 4			・Explain important Thai wisdom of Sukhothai period that should be preserved
	Gr 5		・Appreciate values of Thai culture affecting the way of life in Thai society ・Participate in preservation and dissemination of local wisdom of their communities	・Briefly discuss influences of foreign cultures on modern Thai society ・Explain important Thai wisdom of Ayutthaya and Thonburi periods that should be preserved
	Gr 6	Appreciate and pray to extend loving kindness to all, train their spirit, acquire wisdom; be conscious of spiritual development in accord with guidelines of students' own religions	Analyze cultural changes over time, preserve fine culture	Explain important Thai wisdom of Rattanakosin period that should be preserved
Lower Secondary Education	Gr 7	Pray to extend loving-kindness to all, train their spirit and acquire wisdom through conscious breathing or in accord with guidelines of students' own religions		Analyze the influence of culture and Thai wisdom of Sukhothai period and of modern Thai society
	Gr 8	・Analyze the importance of Buddhism or students' own religions as a foundation of culture, national identity, national heritage ・Pray to extend loving-kindness to all, train their spirit and acquire wisdom through conscious breathing or in accord with the guidelines of students' own religions	Explain similarities and differences between Thai culture and those of other countries in Asia, to create mutual understanding	Specify Thai wisdom and culture of Ayutthaya and Thonburi periods, influence of this on the development of the Thai nation in subsequent periods
	Gr 9	Pray to extend loving-kindness to all, train their spirit and acquire wisdom through conscious breathing or in accord with the guidelines of students' own religions	Preserve Thai culture, choose to absorb appropriate universal culture	Analyze Thai wisdom and culture of Rattanakosin period and its influence on the development of the Thai nation
Upper Secondary Education	Gr 10-12	・Appreciate and pray to extend loving kindness to all, train their spirit and acquire wisdom; be conscious of spiritual development in accord with guidelines of students' own religions ・Analyze the development of proper faith and wisdom in Buddhism or concepts of learners' own religions	Analyze the necessity to improve, change. preserve Thai culture; choose to absorb universal culture	・Analyze factors conducive to creation of Thai wisdom and culture that affect modern Thai society ・Analyze achievements of important people, Thai and foreign, who contributed to creating Thai culture and history ・Plan, set guidelines and participate in preservation of Thai wisdom and culture.

Extracts from Basic Education Core Curriculum 2008 (Ministry of Education, Thailand 2008), modified by Mizuho Ikeda

cultural heritage tends to connect to the formation of 'Thai culture', rather than cultural diversity or critical thinking through comparison between different cultures. Regional and local culture is to be placed complementary to Thai culture to sustain the development of the society.

Interviews with heritage specialists: memory and motivation

This section presents extracts from interviews with two archaeologists working in the cultural heritage field in Thailand, who have also collaborated with LLMP. The interviews aimed to understand how they developed an interest in archaeology, even though archaeology is not a familiar subject in schools or families, and how this connects to their motivation for their current work.

Informant 1

–What is your first memory of cultural heritage when you were child?

I was born in Khon Kaen, which is northeastern province of Thailand. My village was closely located to the famous archaeological site Non Nok Tha but when I was a child, I didn't know what Non Nok Tha means for archaeologists. Then, when I went to high school and learned the history of Khon Kaen and Isan, the teachers took us to the National Museum of Khon Kaen to see a Sema stones, ancient potteries and human remains. When I saw this, I felt 'Wow, that's neat and interesting'. I felt this is the antiquity (history) in my area and in my province.

–Why did you decide to study archaeology in University?

That is always associated with the memory of that first field trip to the museum. When I saw Sema stones, Ban Chiang pottery, I was fascinated by their form, style etc. So, I just wanted to learn more about them. Also, the term 'Borankadi', which is archeology in Thai, is not common for Thai society, so I felt that I wanted to find out more about 'What is archaeology? What can we learn from archaeology? What does archaeology mean? Is it just about digging or something else?'

–What is your motivation for your work?

I think archaeology now has become a popular discipline all over the world, so many universities offer archaeology classes and degrees. Also, new archaeological data and evidence are found on a daily basis. So, as our duty, we need to improve the facilities and resources. Moreover, promotion of international collaboration is also important. That makes us possible to share experience and data. By doing so, we can improve our knowledge or even the discipline itself. So, we shouldn't keep the data and materials only in Thailand – so, one more thing that I would like to do is to expand and open more opportunity to other people/the public to study archaeology. We should have a public outreach program and people can learn their history.

Informant 2

–What is the first memory of cultural heritage when you were child?

It was in the fourth grade of primary school. The school took us to visit the Khmer temple in Korat where I was born. The temple is called Phimai, which is a famous archaeological site in my area. I remember this trip very well. What struck me the most was a carving in the temple. I remember the scenery; I saw a stairway and went up and then saw a big stone carving. It was a lotus shape and I looked down and was impressed by it. It's very clear memory and even right now, I still remember the moment.

–Why did you decide to study archaeology?

It would probably be that the memory I had in Phimai, and as I said, I was always a curious person. Also, my father influenced me. He is a very knowledgeable person and worked as a government official, and wherever we moved, he always told us the history of places and difference between various cities.

-What is your motivation for your work?

It may go back to the reason why I study archaeology. My mother didn't want me to study archaeology and I was the only person in class who wanted to study archaeology. My mother has a friend who is archaeologist and she told me that 'Don't become an archaeologist! You spend your lifetime working with skeletons and being covered by dirt. So, it is not a pleasant environment for women'. So, I studied English in my bachelor's degree and went to England. Then, I was able to choose a major, so I talked to my supervisor about choosing archeology as a major. I said to her 'I don't know about archaeology at all, but I wonder if I can do it?' and she asked me 'Have you been to a Khmer temple?' and I said 'Yes, sure. I come from Korat where Phimai is'. Then she said, 'Ok, so you have an enough background to study it!'

My motivation to work is to engage common people to understand more archaeology and the significance of cultural heritage. Because I came from a different background of study, I understand the feeling of common people. I think this is an advantage. If I studied archaeology for my first degree, I would have a same mind set as other archaeologists. Most of the time, archaeologists don't consider people who don't understand archaeology. When you go to the National Museum here, you see bones and pots explained as dating back to the sixteenth century. But for people who don't know archaeology, it doesn't mean anything. There is no story. After that, you get bored and don't want to study anymore. So, I always try to look at archaeology from the perspective of a person who doesn't know anything about archaeology and try to think how I can make people more aware of the significance of archaeology. So, since I started working here, that's always my motivation, how to communicate with ordinary people.

In both stories, the common factor is that they visited museums or archaeological sites during their childhood. In Thailand, school trips are organized once a year and provide a valuable experience for students, because some of them have never been out of the province. The role of education and school are again key factors in the importance for cultural heritage. A second common factor is the impact of objects. The advantage of an object is its appeal to the five senses. It stimulates the curiosity of the viewer with a wide range of questions, such as the way of production of the object, and the people and social background that produced it. Informants were attracted to an object because it belonged to their local area. Strong impressions of objects and their stories, and a sense of belonging, are key factors for these informants when they connect archaeology and their present work.

Conclusion

Throughout this paper, various aspects of cultural heritage from different points of view have been discussed, looking for appropriate approaches to the conservation and sustainable management of cultural heritage by local communities. From the side of government organizations, cultural heritage is a symbol of national identity and economic benefit, and the role of tangible heritage for tourism is especially significant for Thai society. On the other hand, cultural heritage for the community is mostly intangible heritage, and a part of everyday life. Tangible heritage, apart from temples other buildings, is not well recognized by the community. There is a huge recognition gap between government organizations and communities, which causes difficulty in maintaining cultural heritage. However, whether it is an archaeological site or old architecture, stories and ceremonies have been attached to it, therefore it is not possible to separate both. The loss of tangible heritage or changes in historical landscape means the loss of intangible heritage. Not only is loss of cultural heritage a concern, but also loss of the connection among people and the connection between people and the land. The accumulation of these causes loss of community in the long run. The comprehensive framework of a management plan is therefore important.

One suggestion for sustainable management is to bring in an ombudsman group to watch the development plan and actions of the government. At the moment, LLMP functions as a sort of ombudsman, however

because it is a volunteer group and there are different interests within the group, it is difficult to negotiate in unison. Apart from LLMP, it is necessary to have another interest group. In my opinion, an educational institution has more potential to become involved with conservation of cultural heritage. Through the analysis of education discussed above, there is a framework to teach local history and culture, even if it does not function in favor of local heritage study right now. The impeding factors are various and not all lack of motivation by teachers and students. In order to raise interest in and use of cultural heritage in schools, researchers should provide information that allows teachers to easily apply it in the classes. Another possible role for researchers in cultural heritage management is to work as mediators, and to actively connect wider governmental organizations. Good research and the enhancement of the academic value of cultural heritage is a fundamental task for researchers, and the active involvement with the community and handing on of information in a manageable way is also essential. The local people, after all, are the ones who live with cultural heritage every day.

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