2 Emergence of cultural diversity in mainland Southeast Asia: a view from prehistory

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1 Introduction

The study of cultural diversity is central to the discipline of anthropology (Hannerz 2010), but anthropological archaeologists who specialise in mainland Southeast Asia (MSEA) have not made the study of diversity in the archaeological record a priority. Nevertheless, one can discern in the literature at least two general views on the overall timing and processes of cultural diversification during Southeast Asia's prehistoric period (i.e., before about 500 CE). The most widely held view, here called View One, is that cultural diversification in Southeast Asia is a late Holocene phenomenon, occurring after rice cultivating societies bearing a so-called 'neolithic' cultural package and speaking Austroasiatic languages expanded into the region (Bellwood 2005:132). In this 'Neolithic wave of advance from the north' (Higham et al. 2011:541) model, the ultimate source for the neolithic package is the Yangtze Valley cultures dating 6000–4000 BCE (Rispoli 2007). The chronology for the spread of the proposed neolithic package within MSEA is not yet clear. Dates proposed for the arrival of neolithic societies/package in MSEA include ca. 3000 BCE (Bellwood 2009), late third millennium BCE (Rispoli 2007), and as late as ca. 1650 BCE (Higham and Higham 2009). According to Bellwood (2005:132), regionalisation and diversification of 'cultural style' developed after the initial dispersal of these fairly homogeneous neolithic societies.

Implied in some older literature is another view, one that suggests that processes of cultural diversification in MSEA predate the prominence of rice agriculture in the region. Scholars holding this view, here called View Two, see the region's cultural diversity as embedded in and reflective of the ecological diversity generally inherent in tropical ecosystems (Dunn 1975; Hutterer 1976; Kennedy 1977, 1978). In this second view, rice agriculture and its possible linguistic correlates are de-emphasised and priority is given to investigating the variety and interdependencies among human resource exploitation systems, including various agroecosystems that emerged by the late Holocene (Hutterer 1976, 1983, 1988).

View One is embedded in a high level theory, termed the 'farming/language dispersal hypothesis', that is elegant, elaborate, and global in scope (Bellwood and Renfrew 2002). The hypothesis in its variant forms posits an array of relationships among early cereal

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cultivators, the global distribution of language families, and large scale demographic changes that is said to explain the foundation and dispersal from homelands of the agrarian economies, populations, and lifeways that have dominated the earth for the last several millennia (Bellwood 2002, 2005, 2009). With regard to MSEA, this view maintains that pre-rice farming peoples contributed little to the subsequent cultural and biological character of the region (Bellwood 2005:130). Low density foraging populations and pre-farming lifeways were out-competed or subsumed by the rapidly expanding rice-growing societies.

View Two sees MSEA diversity as a fundamentally autochthonous process and a byproduct of tropical subsistence systems, both generally and with some aspects peculiar to the Southeast Asian geographic region. While View One argues that the appearance of agriculture in MSEA represented a fundamental and rapid discontinuity with preceding hunter-gatherer societies (Bellwood 2005:130; Higham 2009:252), View Two expects a greater subsistence and population continuity during a lengthy, though geographically uneven, overall regional transition from predominantly hunting and gathering to predominantly agricultural modes of subsistence (here termed the HG-AG transition; see Kealhofer 2002). Although View One sees rice agriculture as the driver of early ‘neolithisation’, View Two hypothesises that the prominence of rice agriculture is a relatively recent phenomenon preceded by extensive, multi-faceted poly-cultural agricultural systems including horticulture and shifting dryland cultivation of many crops. [See also Sidwell & Blench (this volume) who posit root crops and access to aquatic transport as key drivers in the transformation of the MSEA landscape.] View Two predicts that cultural differentiation emerged initially in areas with ecological mosaics, as local groups, including hunter-gatherers, exchanged resources that were differentially distributed across the landscape (Kennedy 1978).

Although View One dominates in recent regional archaeological literature, proponents of both views recognise that these hypotheses need more data (Higham et al. 2011; Hutterer 1988). Regional archaeologists acknowledge that data sets in MSEA are biased by small samples and uneven geographic coverage. Most archaeologists in any area are painfully aware of the perpetual gaps in the archaeological record, but in Southeast Asia the gaps pertinent to the topic addressed here are particularly gaping.

Nonetheless, evidence for cultural diversity, such as in the sense of Jonsson’s (this volume) ‘localised domains of identity’, is present in Thailand’s archaeological record during the metal age (2000 BCE–500 CE; see White and Eyre 2011). The distinct metal age ceramic subregions discussed in White and Eyre (2011) suggest that sets of settlements shared distinctive styles and technologies in mortuary pottery in contradistinction to other sets of contemporaneous settlements with different shared pottery styles and technologies. The socio-cultural subgroupings implied in the subregional ceramic traditions might at first glance appear to support View One—diversification following neolithisation. But that article does not address the possibility that cultural diversification in MSEA existed before the metal age, nor does that article fully address the genesis of metal age cultural diversity. Can diversity be identified in the earliest appearance of agriculture, or in earlier hunter-gatherer contexts? Are the fundamental processes of the early cultural diversification best characterised as divergence from a homogeneous predecessor? Or did domains of identity constellate from even more diverse predecessor societies? While definitive answers cannot be given with the limited evidence we have now, this chapter will argue that Southeast Asia has an extraordinary diversity of ecological zones and that the region’s prehistoric cultural diversity is closely linked to that environmental diversity. Some of the contributing factors to Southeast Asia's ecological diversity are summarised in the first part of this chapter.

This chapter also argues that variation in technological choice underlies many aspects of cultural diversity, and it can be observed in the record from the initial settlement of anatomically modern humans in Southeast Asia. Technological choice is inferred among the Holocene hunter-gatherers despite a relatively uniform and widespread stone tool tradition, and is seen in the archaeological record from the earliest documented agricultural/horticultural societies. In addition, I propose that early bamboo exploitation was an important medium by which societies made technological choices, developed technological styles, and initially articulated cultural diversity in material culture.

Furthermore, I propose that future studies of the prehistoric period should not assume that rice economies are the *sine qua non* of regional culture history and should rather focus on broader ecological and technological approaches that are geared towards the investigation of diversity. The use of new methods, such as analyses of residues, starches, phytoliths, aDNA, and isotopes of archaeobotanical and archaeozoological remains as well as use-wear of lithic artifacts, all of which are just beginning in Southeast Asia, can and will transform our understanding of human occupation of MSEA and especially of past subsistence practices and lifeways.

1.1 Diversity, styles, technologies, and communities

But first I consider briefly what evidence archaeologists might use to ascertain cultural diversity during the prehistoric period. 'Cultural diversity' may be construed in many ways, and several but not all dimensions should be archaeologically visible. The development of 'localised domains of identity' (Jonsson, this volume) is one aspect of diversity of interest to anthropological archaeologists. How to recognise such domains in the pre-literate period from archaeological evidence is neither simple nor straightforward, as different criteria for what constitutes diversity, different scales of analysis, different data, and different questions may result in more than one reconstruction of past social groupings (Hegmon 1998). Nevertheless, archaeologists explicitly or implicitly discuss such domains, when they discuss 'archaeological cultures'. Archaeologists often use geographically patterned variation in decorative styles in material culture such as pottery as a means to differentiate past cultures and help define social boundaries (as reviewed by Stark 1998:2). While not foolproof, variation in morphological and decorative style has been shown to coincide with perceived regional social boundaries in some ethnoarchaeological studies of acephalous agrarian societies (e.g., Graves 1994).

However, it is increasingly recognised that the study of decorative style is insufficient for identification of past social boundaries, and that technological style provides an enhanced avenue for archaeologists to document communities that share ways of life, social interaction systems, and bodies of knowledge (Stark 1998). Whereas decorative styles can span cultural boundaries through trade and imitation, technological styles endure through transmission of technological know-how across space and time via socially constructed learning frameworks. Through the detailed study of past technological systems, identification of 'communities of practice' (Wenger 1998) who shared 'specific ways of doing things' is becoming an important avenue by which archaeologists can distinguish past groupings of peoples (Hegmon 1998; Stark 1998).

If we apply a community of practice perspective to the study of past societies, the spread of agriculture can be seen as the spread of technological systems–systems of know-how and practice whereby biological resources are produced intentionally on land that, without the intervention of agrarian technologies, would be sustaining natural resources that may be less desirable, useful, numerous, or concentrated for the societies residing on the land. There are of course many variant agricultural systems, each deserving of focused investigation. The systems of know-how are inevitably embedded in group choices and styles of agrarian practice within specific environmental contexts that shape decisions about which lands to cultivate, what kinds of implements to use, which crops can and cannot be grown on particular landscapes, and what crops are fundamental to a lifeway and which are peripheral.

Subsistence technology is a major structural element in organizing any group's way of life. One major problem for understanding past agrarian subsistence systems in MSEA is the paucity of direct archaeobotanical evidence for agriculture (Castillo and Fuller 2010). View One infers the presence and spread of agriculture primarily from indirect evidence such as decorative style on pottery and settlement locations near arable land. It is often assumed that the economy was based on rice, even when many sites and regions have no hard evidence for rice cultivation (e.g., Higham 2002:228). By framing rice agriculture as an economy rather than as a range of technological systems practiced by different communities of learning, View One ignores the different effects that various kinds of cultivation systems for rice or any crop would have had on the processes of spread and adoption of agriculture. Wet rice/dry rice, extensive/intensive, shifting/stationary field, monocrop/polycrop, these technological variants would have had very different implications and outcomes for labor organisation, demography, expandability, environmental impact, settlement system, and other aspects of society and environment that are of central importance to understanding the regional transition to agriculture.

It is particularly important not to conflate cultivation of dry upland rice with cultivation of inundated rice. The two cropping systems require different varieties of rice, and dryland rice generally would have required shifting cultivation in a multi-crop field, whereas wet rice at least in these latitudes was probably raised in stationary plots (White 1995). The investigations of DNA of modern and ancient rice (Fuller et al. 2010) are changing the picture of the palaeogeography of early rice cultivation, with *indica* and *japonica*, and wet and dry variants having a more complex history than the single homeland assumption allows. Although discussions of View One rarely state whether the expansionary rice-based economies are cultivating wet or dry rice, the demographic dynamics inferred, the focus on alluvial plain settlements and other attributes discussed are more consistent with an inference of wet rice.

This raises a key problem with finding evidence to support View Two expectations regarding diversification: societies practicing extensive polycultural agriculture, such as might be postulated for early agricultural groups in MSEA, often do not leave much for the archaeologist to find. Certainly reconstruction of subsistence systems by analyses of plant and animal remains, which in MSEA currently lags other parts of the world, will eventually help resolve the nature and details of the HG-AG transition in MSEA (Castillo and Fuller 2010). For the present, proponents of either view are required to infer subsistence technology largely from models, some faunal and other palaeoenvironmental data (e.g., Kealhofer 2002, White et al. 2004), settlement location, and the handful of archaeobotanical studies available from the region (Castillo and Fuller 2010).

Some of the newer data already available include palaeoenvironmetal, technological, archaeobotanical, and settlement evidence. This paper briefly outlines some of the newer ecological and technological evidence pertinent to discussion of prehistoric cultural diversity in MSEA. The linguistic and human biological evidence is not discussed here, as these topics are addressed by appropriate specialists in other chapters in this volume.

Because technological choices are embedded in environmental contexts that provide both constraints and possibilities, the study of past technological systems is inseparable from environmental reconstruction. An appreciation of Southeast Asian environmental variability is needed to provide a contextual foundation for studying human cultural diversity in the region. Recent palaeoenvironmental data are transforming understanding of the profound changes in landscape, vegetation, and other natural resources that occurred in the late Quaternary of MSEA. These changes in biotic resources and environment must have affected human land use and subsistence. While much detailed research relating the new palaeoenvironmental evidence to archaeological data still needs to be undertaken, some preliminary insights are evident. Some of the new data undermine the parsimonious elegance of the View One hypothesis of diversity in MSEA.

2 Environmental background to diversity in Southeast Asia

2.1 Inherent regional diversity

The Southeast Asian environment has long been recognised as complex and diverse simply because of its tropical location. With their intense solar radiation and high rainfall, tropical landscapes are known for their high species diversity relative to more temperate latitudes. High species diversity means that subregions tend to have large numbers of resident species, but proportionally fewer individuals or concentrations of those species, in comparison with geographic areas with lower species diversity such as, for example, temperate latitude grasslands or pinelands.

However, there are many other factors contributing to Southeast Asia's biodiversity besides its tropical latitude. The plate tectonics of the region have created a variety of contrasting landforms ranging from mountains as high as 3000 m in northern Myanmar to vast low-lying continental shelves currently underneath the South China Sea. A fan of major rivers drains the eastern Himalaya Mountains that formed from the collision of South Asia with the Eurasian plate. The hub of the fan lies in Yunnan where north to south trending drainages diverge and establish the closely interdigitating highlands and valleys for which Southeast Asian geography is known. The suite of rivers includes the Brahmaputra extending west to the Ganges, the Salween extending south, the Mekong crossing to the southeast across MSEA, and the Yangtze extending to the east across what is today the southern half of China. Other rivers in between these four major 'spokes' include the Irrawaddy, Chao Phraya, and Red Rivers. These riverine systems dissect and expose the underlying geological formations, including remnants of micro-continents dating as far back as the pre-Cambrian (Hutchison 2005). This complex geological and geomorphological history has provided Southeast Asia with a wealth of topographically and geomorphologically differentiated environments (Hutchison 2005) that ultimately provide a more complex natural geographic infrastructure than most other tropical landmasses (Gupta 2005:38).

An additional component of MSEA geographic complexity is the widespread carbonate (limestone) deposits, including 'some of the more extensive karst regions in the world' (Gillieson 2005:157). Differing greatly in age, including parts dating from the Paleozoic, the karst landforms exposed throughout much of MSEA vary greatly among themselves and include limestone plateaus, towers, and swamps. The karstic topography contributes to high regional rates of allopatric speciation (species formed from geographic separation of breeding populations; Gillieson 2005:172). Areas of extensive limestone exposure create isolated niches for biota, as the escarpments and cross-cutting river systems create physical barriers for breeding populations of many species. The karstic microniches provided refuge areas for biota over periods of climate change from which genetic bottlenecks and founders' events occurred as climate trends fluctuated over time. Hence species in karstic environments often are highly adapted to the local habitat (endemism) and consequently have small ranges. Karsts, which in MSEA often have extensive cave systems, influence agricultural potential in a variety of ways, usually endowing the area with soils vulnerable to erosion and poor moisture retention.

2.2 Late Quaternary sea level change

Another outstanding geographic characteristic of Southeast Asia is the extensive and shallow Sunda continental shelf that now lies under the South China Sea and the Gulf of Thailand. Throughout most of the late Pleistocene, most of this continental shelf was exposed land, as sea level vacillated between 40 and 90 meters below its present level (mbpl., Figure 1; Hope 2005:28). The lower sea level meant that throughout the late Pleistocene, continental MSEA included Sumatra, Java, Borneo, and many other land areas that today are considered parts of island Southeast Asia (ISEA). The Southeast Asian post-LGM (last glacial maximum) sea level rise reduced the region's total land area by a third (Voris 2000:1155). More than two million square kilometers of lowlands were inundated, much of it alluvial plain (Sathiamurthy and Voris 2006:3). The rise in sea level reshaped the Southeast Asian landscape, creating several large and many small islands, dramatically expanding the coastline, and reducing the expanse of alluvial lowlands (Figure 2). Sea level change has contributed directly to the intrinsic environmental and biotic diversity of the Southeast Asian region through reconfiguring both terrestrial and aquatic communication corridors and barriers for humans and other species.

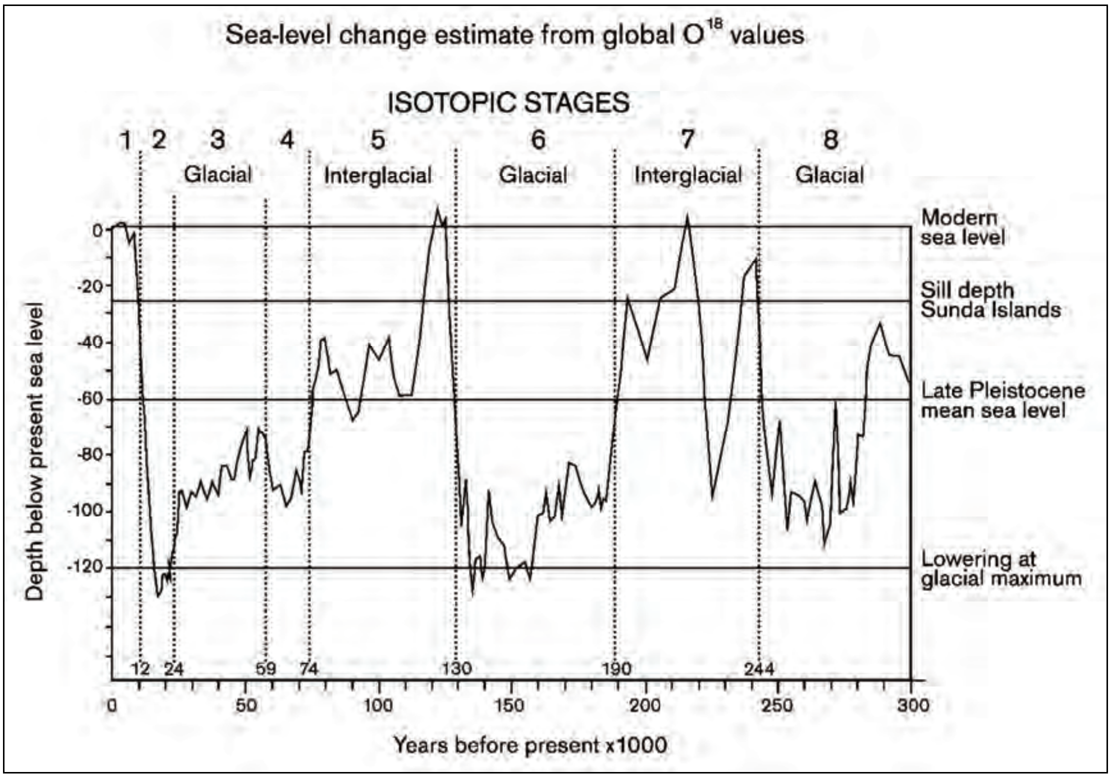

Figure 1: Diagram showing changes in sea level during late Quaternary global oxygen isotopic stages. Adapted from Hope 2005 and Martinson et al. 1987.

There is not yet full agreement on the exact dating of the LGM and the specific depth of the LGM sea level, but the general picture is well enough known for our purposes (Hanebuth et al. 2011). Figure 2 compiles current data from several sources on the changes in exposed land of the Sunda shelf since the LGM. The most significant changes in land configuration occurred at the Pleistocene/Holocene transition as the sea level passed the 50 mbpl mark, when areas such as the Gulf of Thailand and the Gulf of Tonkin became inundated. Borneo lost its land bridge to Sumatra and the mainland as early as 11,000 BP at roughly 30 mbpl, while Sumatra became disconnected from the Malay Peninsula during the early Holocene after c. 10,000 BP (Bird et al. 2004; Sathiamurthy and Voris 2006). Today’s sea level is thought to have been reached only around 6000 BP.

Pollen and other data show that during the LGM, average temperatures may have been slightly cooler and humidity slightly lower than today, and lowland rain forests and lower montane rainforests covered the exposed shelf (Wang et al. 2009). Inundation, although reducing land area and alluvial habitats, dramatically expanded coastline habitats. Such periodic geographic changes in contiguous land mass and habitat configuration due to late Quaternary marine transgressions and regressions are thought to be another important contributing factor to high allopatric speciation in Southeast Asia and a resulting high regional biodiversity (Hanebuth et al. 2011; Sathiamurthy and Voris 2006:2). Human population density would also have been affected, especially in areas such as the Gulf of Tonkin where large areas of continental shelf were inundated.

2.3 Late Quaternary climate change

In addition to the landscape changes brought about by rising sea levels, changes in climate following the LGM and their impact on the Southeast Asian biosphere are increasingly being documented (Cook et al. 2011; Wang et al. 1999). Changes in climate include not only rising temperatures and increased precipitation, but also seasonal concentration of precipitation during the summer from the strengthening of the Indian and East Asian monsoons. These climate changes had profound effects on habitat range and variability in MSEA.

In addition to changes in precipitation and temperature, atmospheric CO^2 concentrations changed (Maslin and Thomas 2003). The higher CO^2 levels during deglaciation (caused by release of methane as tropical wetlands expanded) favoured not only great increases in plant biomass, but the expansion of C3 plants at much higher rates than C4 plants (Maslin and Thomas 2003:1733). C3 and C4 plants differ in photosynthetic pathways, and C4 plants tend to thrive in drier contexts, C3 in moister contexts. The C3/C4 distinction is important to assessing availability of certain foods and in turn subsistence constraints and potentials; for example Job’s tears and some millets are C4 plants, and rice and bamboo are C3 plants.

Changes in climate in concert with inundation of the Sunda shelf contributed to highly localised variation in environmental changes for MSEA. The seasonality and total amount of annual rainfall in any particular region has complex relationships with wind patterns, temperature, topography, and distance from oceans. Even today Southeast Asia can have dramatic changes in precipitation over relatively short distances. For example, interior parts of Myanmar can average around 1000 mm annual precipitation, and three to four hundred kilometers to the west at the same latitudes along the Bay of Bengal there are zones with more than 5000 mm. Figure 2 shows that the Bay of Bengal was less affected by post-LGM inundation than the South China Sea, where the inundation of the Gulf of Thailand would have drastically changed the exposure of Cambodia to summer monsoon moisture systems. This point has been suggested to account for a delay in manifestation of Holocene climate patterns in Cambodia (White et al. 2004). As a result of the variability in the slope and width of the Sunda continental shelf, the effects of inundation on local moisture systems varied from place to place, which in turn further stimulated overall diversification in the regional biosphere. These climate changes must have affected resources available to human societies at very local levels.

2.4 Late Quaternary vegetation change

Whereas many larger-scale aspects of the post LGM environmental changes are being clarified as new methodologies such as speleothem records (Wang et al. 2008) are brought into the discussion, the sub-regional details of late Quaternary vegetation changes in MSEA are only beginning to be documented. It is these local stories that are needed to flesh out the biotic resources and subsistence options the human inhabitants of particular regions had as environments of particular places changed over time.

Palaeopalynological and other palaeobiological records indicate that although the late Pleistocene climate in Southeast Asia was generally drier and cooler than today, the type and degree of habitat changes that specific regions experienced during the climate fluctuations were quite different. Northeast Thailand, for example, is one of the few interior areas of MSEA from which there is a palynological record extending back 40,000 years (Penny 2001). The sediment core from Nong Pa Kho indicates that pine/oak vegetation dominated this area during the late Pleistocene. At the beginning of the Holocene about 10,000 years ago, tropical broad leaf forest rapidly replaced the pine/oak forest. In contrast, a core from Phayao at a higher elevation in northern Thailand (Penny and Kealhofer 2005; White et al. 2004) does not reveal dramatic or rapid vegetation change at the Pleistocene/Holocene boundary, instead suggesting greater continuity. Sediment cores from Cambodia suggest a delay of about 1000 years there for Holocene changes in vegetation (Maxwell 1999, 2001).

2.5 Implications of recent palaeoenvironmental research for MSEA archaeology

There are several points archaeologists need to keep in mind when examining the palaeoenvironmental record in relationship to past human societies. First, the terminal Pleistocene to early Holocene in MSEA was a period of very lively and diverse habitat change, the details for which were highly localised. Second, late Quaternary changes in habitat and resource availability near individual archaeological sites therefore must be studied location by location. Archaeologists cannot necessarily generalise palaeoenvironmental evidence for habitat change in one location in Southeast Asia to another dated to the same time frame. Third, while in some regions habitat change may have been profound and widespread (for example, northeast Thailand) other areas may have had more stable habitats (parts of northern Thailand). Other areas such as northwest Borneo experienced proportional shifts in habitat expansion and contraction (Wurster et al. 2010).

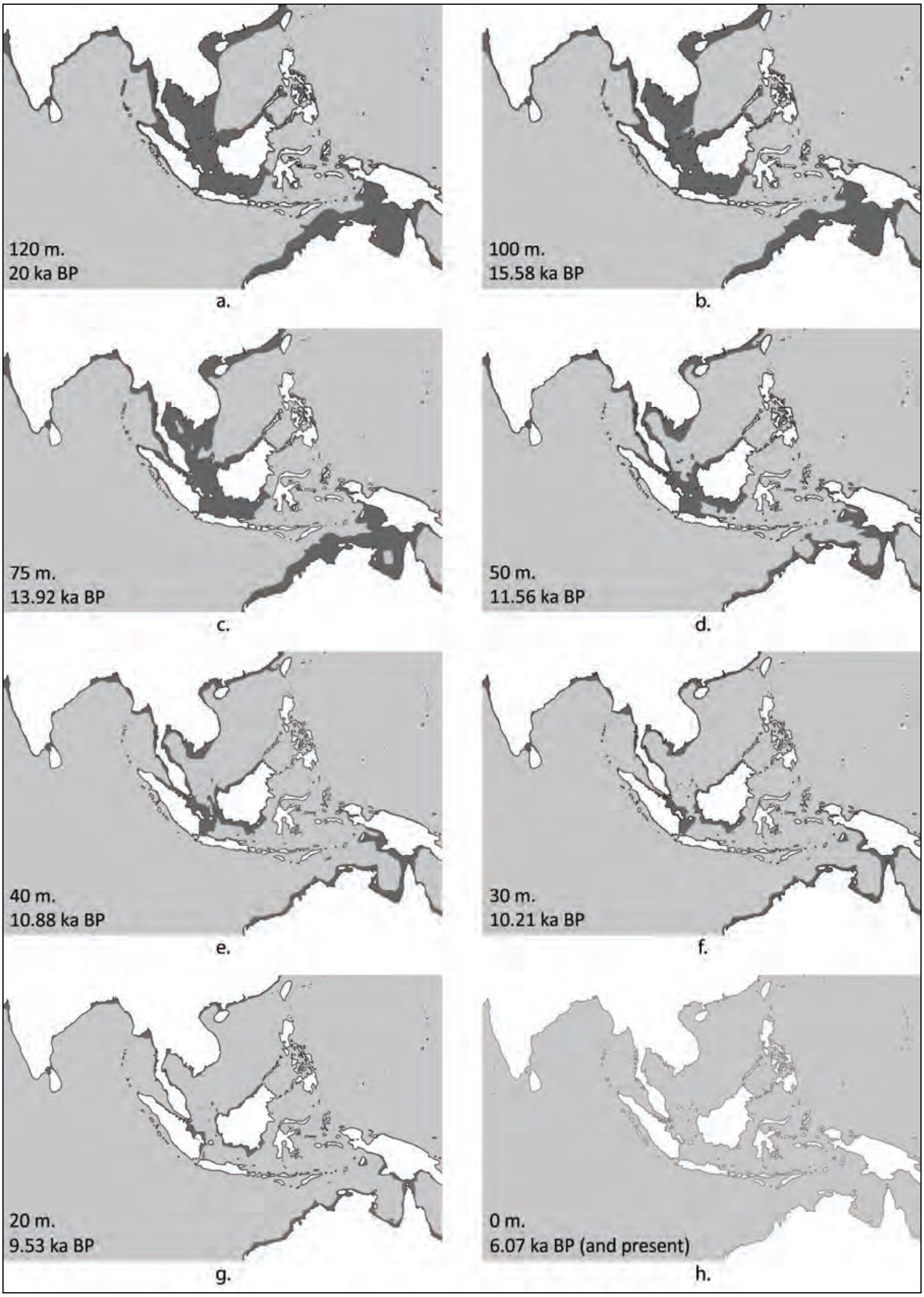

Figure 2: Exposure of Sunda Shelf at several depths below modern sea level from the LGM. Inundation with depths and dates adapted from Hanebuth et al. 2011; Sathiamurthy and Voris 2006; Voris 2000.

3 Late Pleistocene Occupation by Modern Humans

According to many current models for the appearance of *Homo sapiens sapiens* in MSEA (e.g., Bird et al. 2005; Pope and Terrell 2007), modern humans expanded into MSEA during a late Quaternary climate phase referred to as 'Oxygen Isotope Stage 3' or OIS3, which dates c. 59,000–24,000 yr BP. Sea level during this period fluctuated between roughly 70 m and 95 m below current levels (Hope 2005:28; see Figure 1). Throughout OIS3, the Sunda continental shelf was exposed and MSEA extended through to Borneo. [Note, although Palawan has evidence of human occupation during OIS3, no land bridge existed with the mainland during the last glacial period (Piper et al. 2011). Thus the late Quaternary archaeology of that island will not be considered here.] The major spread of humans may be further delimited to a relatively stable warm/wet interval between c. 47,000–37,000 yr BP that substantially overlaps with a period of swamp, estuarine, lagoon, and reef development, according to Pope and Terrell (2007:8). They (2007:11) 'propose that the development of productive coastal ecosystems … was a major factor in the rapid spread of modern humans from the west along a southern migration route in the interval 47,000–37,000 yr BP'. Others posit human expansion via a savannah corridor that reached from interior Asia into western Borneo (Bird et al. 2005; Wuster et al. 2010).

3.1 OIS3 sites

Only a handful of archaeological sites have dates from OIS3 in MSEA (Fig. 3). The earliest include: (1) Lang Rongrien in southern Thailand (Unit 10 dating to about 43,000 BP and Unit 9 dating to about 37,000 BP re Mudar and Anderson 2007:303); (2) Niah Cave in northern Borneo, with several dates indicating early occupation c. 45,000–38,000 BP (Barker 2005; Barker et al. 2007); (3) Tham Lod in northern Thailand, which has a TL date of about 36,000 years ago from Area 3, Layer 4 (Shoocongdej 2006); and (4) Bukit Bunuh, an open air lithic workshop in Malaya with an OSL date of roughly 40,000 years old (Roberts et al. 2005; Saidin 2006).

Even if most Late Pleistocene MSEA sites now lie under several meters of water, these four excavated sites together demonstrate that the OIS3 humans in MSEA occupied a variety of habitats. Tham Lod in particular indicates that habitats at more than 600 m above modern sea level and hundreds of kilometers from coasts were occupied during the OIS3 in MSEA.

Evidence from these four OIS3 sites suggests that the occupants exhibit a diversity of hunter-gatherer technologies, mobility patterns, and subsistence strategies. Although the quantity and quality of archaeological data available varies among the different excavations, variation between the sites is clear. Regarding lithics from the OIS3 sites, Shoocongdej (2006:35) reports that the context producing the early date at Tham Lod contained only flakes, mostly of sandstone. Saidin (2006) reports a wide range of pebble tools, cores, flake tools, and debitage at the purported lithic workshop at Bukit Bunuh. Lang Rongrien's layers 10 and 9 show a predominance of small irregular flake tools with some core tools made mostly from local chert (Anderson 1990). At Niah, in addition to stone flakes, a worked bone point was found in the OIS3 layers (Rabett et al. 2006:56). The overall evidence suggests that the inhabitants used expedient flake and core technologies lacking morphological types and probably used lithic resources close to sites (Rabbet and Barker 2010:69).

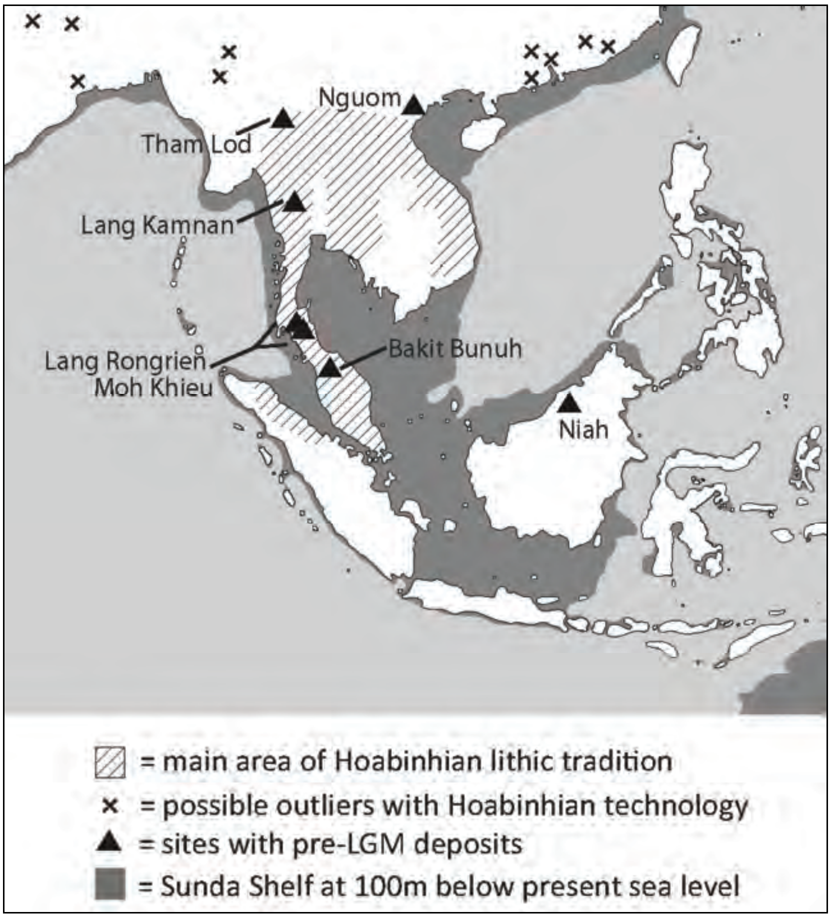

Figure 3: Map showing pre-LGM sites mentioned in the text, Hoabinhian main range, and Hoabinhian outliers. Sunda Shelf exposure depicted at 100 mbpl. c.15,500 years ago.

Available faunal evidence from Niah and Lang Rongrien indicates that humans exploited a wide range of habitats and species during OIS3, but that species concentrations varied between sites and sub-periods. Although bones of large animals are present at both sites, medium and small animals were more common. The range of fauna exploited demonstrates that diverse foraging technologies were used in diverse habitats (arboreal, terrestrial, riverine, and more; Barker et al. 2007; Rabett et al. 2006). Rabett et al. (2006) note that the wide range of fauna and flora from Niah demonstrates the existence of a wide range of hunting and gathering skills and behaviours (Barker 2005), from mollusk collection and fishing to hunting of arboreal mammals such as monkeys and small mammals such as rodents and porcupine. However, terrestrial animals predominated, especially pig (Rabbett et al. 2006). Mudar and Anderson (2007) found that Lang Rongrien Units 10 and 9 have mostly deer, bovids, turtles, and tortoise. The smaller range of mammals and absence of pig at Lang Rongrien are notable. They suggest that the types of faunal diversity at the two sites reflect differences in local habitat and settlement use. Niah may have been occupied for longer periods of time, more like an intermittent base camp, and the inhabitants must at least periodically have had access to patches of rainforest of sufficient size to sustain pig populations. Lang Rongrien may have been used more sporadically as a short term hunting camp, and remains of Eld's deer (*Cervus eldii*) indicate that dry dipterocarp forest and open plains were within the catchment zone. Evidence of butchery of both complete and partially dismembered carcasses around hearths was found at both Niah and Lang Rongrien (Barker et al 2007; Mudar and Anderson 2007). No details of faunal remains from the deposits associated with the OIS3 dates at Tham Lod or Bukit Bunuh are reported, and Shoocondej (2006:34) states that faunal remains were rare and fragile in the Tham Lod Area 3 layer 4 deposit which produced the early date.

The most startling indications of OIS3 technological capabilities are the recent findings at Niah of evidence for tubers and nuts requiring extensive processing to remove toxins (Barton 2005; Barker et al. 2007). This evidence demonstrates that early anatomically modern humans in Southeast Asia practiced delayed-return behaviors requiring forward planning and resource processing over the course of days to weeks. Such planning in resource manipulation and consumption is not expected among immediate-return hunter-gatherer societies at the smallest scale, technologically-simplest, and most egalitarian end of the foraging spectrum. The findings of such plant processing suggest a more sophisticated range of social and technological behaviors than heretofore expected for humans in this region at this time depth.

3.2 Other pre-LGM sites

Between 37,000 BP and roughly 20,000 BP (the LGM), a few more dated sites are known from MSEA. During this period sea level fluctuated around 95 mbpl until c. 24,000 BP when sea level lowering accelerated (OIS2) culminating in the LGM. During the LGM, continental shelves reached maximal exposure, alluvial plains were at their maximum extent, and the climate may have been the driest since 130,000 BP. Relict closed canopy rainforest patches likely were at their most reduced, and open habitats were at their most extensive (Wuster et al. 2010). This condition rapidly reversed after roughly 20,000 BP and in little more than 13,000 years, the sea rose about 120 meters to modern levels.

The regions where OIS3 sites have already been noted continue to have evidence of human use into OIS2. Niah (Barker et al. 2007) and Tham Lod (Shoocongdej 2006) have dated deposits showing continued use of areas of northern Borneo and northern Thailand into OIS2. Located near Lang Rongrien, Moh Khieu’s Cultural Level 1 dates to about 25,000 BP (Pookajorn 1996), indicating continued human occupation in that area of southern Thailand. Other areas with pre-LGM dated sites include northern Vietnam where a flake-based technology, Nguomien, is associated with a date of older than 32,000 BP (Anisyutkin and Timofeyev 2006). In western Thailand, Lang Kamnan Cave has deposits dating from c. 27,000 BP (Shoocongdej 2010).

3.3 Late Pleistocene culture and society

Although OIS3 evidence is too sparse to argue for the existence of ‘localised domains of identity’ in the data of late Pleistocene of MSEA, there is evidence of diversity in terms of habitat selection and technological choice. Variability among the OIS3 sites indicates variability in settlement location relative to habitat variation, in fauna exploited, and in lithic technology.

Barker et al. (2007) argue for a tactical interpretation of the OIS3 subsistence evidence whereby resource diversity was strategically targeted. They see OIS3 hunter-gatherers as:

> …exploiting a diverse interior landscape using a battery of technologies that may have included mammal and fish trapping, some form of projectile technology, tuber digging, plant detoxification, and forest burning. The levels of resource use, forward planning, and ingenuity that would have been necessary for such strategies would not only parallel many of

> the developments seen in Late Pleistocene records of Europe and Africa, but also serve to illustrate human adaptive plasticity with *the emergence in Southeast Asia of strategies directed specifically towards exploiting the structure and diversity of lowland tropical environments* (emphasis added; Barker et al. 2007:259).

Thus even though we do not know about human occupation of the now-submerged Sunda alluvial lowlands, the evidence that we do have of MSEA during the late Pleistocene shows that the flexibility and 'situational shifting' observed in more recent foraging groups in Southeast Asia may be a general characteristic of pre-agricultural populations in this area extending back tens of thousands of years (Junker 2002:164). The pre-LGM evidence from MSEA is consistent with local adaptations to diverse mosaic environments by generalist hunter-gatherers who could 'habitat-tailor' (Barker et al. 2007).

4 LGM to Early Holocene: Emergence of the Hoabinhian

The drowning of the Sunda shelf between roughly 20,000 and 6,000 BP coincides with the emergence of a distinctive lithic technological tradition recognizable throughout MSEA that archaeologists call 'Hoabinhian'. As the post-LGM environmental changes are more fully understood, the highly variable and dynamic environmental context in which this technological system developed is becoming clearer.

4.1 Summary of Post-LGM environmental changes

Despite the inevitable climate wavers and events, the overall trend of rising sea levels after the LGM is clear (Figure 1), and ultimately the inundation transformed the extent of the land area, the character and configuration of MSEA, and the routes by land and water connecting one part of Southeast Asia to another. The vegetation on lands remaining above sea level must have been transformed in many areas as the monsoonal system took its present parameters and many stretches of previously dry inlands became coastal lands.

For the purposes of this paper, there are three general points to keep in mind about the post-LGM environment of MSEA. First, the post-LGM period to which Hoabinhian assemblages in Southeast Asia are usually attributed (terminal Pleistocene to early Holocene) was a period of great environmental change for the region. Palaeoenvironmental data currently indicate that when the sea level was low, vegetation formed a mosaic of drier, more open plant communities with refugia of denser wet tropical plant communities (Wurster et al. 2010). As climate changed with warming temperatures and increases in precipitation, vegetation was altered but the specifics of those alterations vary greatly across MSEA (White et al. 2004). As CO^2 concentrations, temperatures, and precipitation increased after the LGM, the wet tropical variants increased in areal extent and drier variants decreased, again with details locally contingent. Closing of tropical forest canopy at the lower latitudes would have favoured a shift at least proportionally from fauna requiring open expanses to fauna needing continuous tree cover or arboreal habitats. Second, total land area above sea level in Sundaland decreased by about half which in itself must have altered total regional population density. However, there would likely have been local variability in the demographic effects of decreasing land area depending in part on the width of the continental shelf. Areas with steeper, narrower continental shelves such as western Sumatra lost little land area while areas with wide gently sloped shelves such as the land now under the Gulf of Thailand lost large expanses. Third, overall, the areal extent of alluvial plains greatly decreased but coastline and hence coastal habitats greatly increased. All these changes must have meant alterations in habitat ranges, distributions, and densities of biological resources, both plants and animals, available to the human occupants of the region.

4.2 The Hoabinhian lithic tradition

Most MSEA sites whose deposits can be dated to the post-LGM inundation of the Sunda shelf are attributed to the 'Hoabinhian'. Unfortunately, while the term 'Hoabinhian' is widely recognised and used, the phenomenon is ill-defined (vide Shoocongdej 2010). Reports from excavations are usually too vague in their descriptions to know if scholar A's Hoabinhian is truly comparable to scholar B's; descriptions of Hoabinhian lithic assemblages lack the details needed to concretely assess variability within the tradition. Moreover, late Pleistocene/early Holocene deposits may be assigned to the 'Hoabinhian culture complex' primarily on the basis of dates, even if no typical flaked cobbles or debitage are found (Rabett et al. 2011:163).

Nevertheless, Hoabinhian assemblages are widely recognised by the presence of highly characteristic flaked artifacts called 'sumatraliths'. Sumatraliths reveal a characteristic production sequence that begins with apparently careful selection of water worn river cobbles with several desirable qualities of size, shape, and material (Forestier 2000). The cobbles tend to be flattish ovoids of hard, often coarse-grained materials such as quartzite or andesite. One of the flattish surfaces typically is selected as the striking platform, from which the cobble is unifacially flaked around all or most of its perimeter (Figure 4a). The steep working edge produced is thus cortex (the water-worn surface) on one side with the flaked surface on the opposite side. The established perimeter can be reflaked along the same platform surface as needed to resharpen, trim, and rejuvenate the edge (White and Gorman 2004). In this manner, the length of edge obtainable from a river cobble can be maximised. 'Classic' Hoabinhian assemblages are also distinguished by the rarity of retouched flakes and the rarity of bifacial flaking on cobbles. Occasionally other kinds of lithic artifacts have been found in purportedly Hoabinhian assemblages, such as pecked stone rings (Figure 4d).

It appears that the flaked cobbles excavated from Hoabinhian deposits were locally acquired, and access to this raw material may have been one determinant of landscape choice by the users of this tradition. There is no clear evidence that non-local lithic resources were exchanged over significant distances during the post-LGM Hoabinhian.

Cobble beds form at locations along riverine systems that are broadly predictable from hydrodynamic models. Cobble-sized 'sediment' (defined as nodules 64 to 256 millimeters in diameter) is commonly transported by rivers and deposited along drainage basins according to parameters of water velocity, turbulence, river bed slope, and other factors. Sites with Hoabinhian lithics are often in caves and rock shelters close to or within couple of kilometers from rivers and extant cobble beds. The heavy cobbles, weighing as much as a kilogram, were thus carried, often up steep inclines, to these caves or rock shelters. The activities for which they were used there apparently often required considerable on-site resharpening and modification of the cobbles, as high rates of debitage recovery at some Hoabinhian sites have been noted (Corvinus 2007:336–9). The repeated circumferential reduction sequence produces a characteristic Hoabinhian flake debitage with high prevalence of flat flakes with cortical striking platforms (Figure 5). On larger flakes, it is common to observe step flake scars or an 'overhang' of small flake scars along the flake's striking platform (Figure 5e–g). The very density of lithic debris in many Hoabinhian deposits is one of the characteristics that can differentiate them from pre-LGM deposits (Anderson 2005).

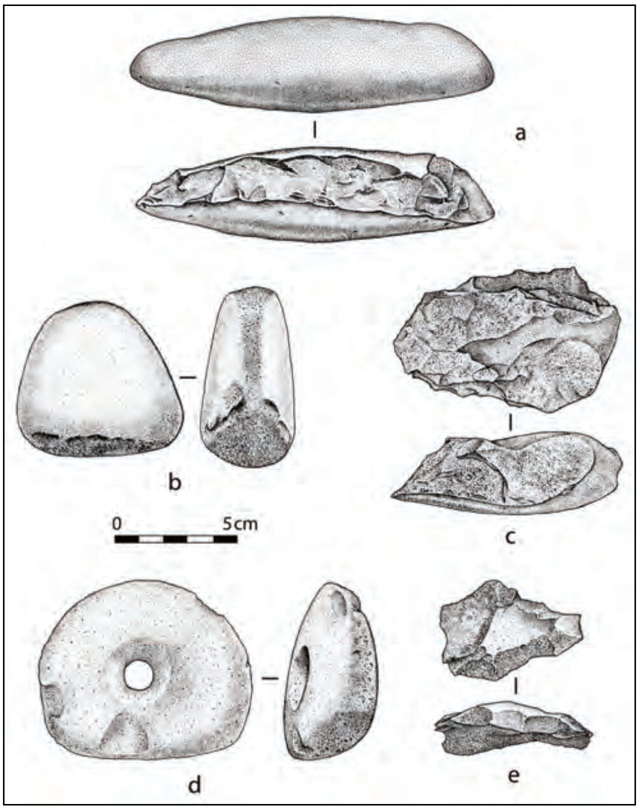

Figure 4: Examples of Hoabinhian lithics from Tham Phaa Can, a rock shelter site in northern Thailand.

a. side view of river cobble depicted before and after initial unifacial flaking;
b. 'hammerstone';
c. sumatralith, top and side views;
d. 'donut' stone;
e. dorsal flake removal probably from sumatralith; (White and Gorman 2004).

The circumferentially flaked ovoid river cobbles with characteristic reduction debitage seem to define a widespread technological tradition (White and Gorman 2004) that does, however, show some regional variation (Anderson 1990:47). While morphological variation of flaked cobbles is evident, it is widely agreed that a typological approach to classifying morphological variants is inappropriate, since the cobbles are in an ongoing state of reduction and modification (Marwick 2008a; Pawlik 2009; White and Gorman 2004). Yet Southeast Asian archaeologists have not established a systematic methodology to describe full lithic assemblages that have been grouped under the Hoabinhian label. The lack of a systematic recording framework prevents meaningful comparisons and assessments of intra- and inter-assemblage variability.

Nonetheless, review of the various attempts at describing Hoabinhian assemblages reveals that there probably exists significant variation even if its meaning is still far from clear (Nishimura 2005). In southern Thailand and the Malay Peninsula, for example, bifacial flaking is noted as common (Bulbeck this volume; Anderson 1990:47), and slatey rock is frequently used. Splitting a cobble before unifacial flaking has been noted in northern Thailand (Forestier et al. 2008). Variability in intensity of reduction is evident in some debitage studies (Marwick 2008a; Nishimura 2005). Marwick (2008b) proposes that reduction intensity is related to distance from raw material, with more reduction at sites further from cobble beds in an effort to conserve resources. Variation in type of stone also seems to be related to availability of local raw materials. Further effort to systematically describe the flaked river cobbles may yet reveal important variants within reduction sequences, or perhaps functional variants. As one example from personal experience, I have observed at sites in northern Laos flaked cobble variants similar to Kamminga's (2007) 'flaked unifaces with strongly convex cortex surface' from Sai Yok in western Thailand. In these examples, the knappers did not choose a flat side of the cobble as the striking platform, but rather retained a markedly curved surface on the unflaked side of the implement.

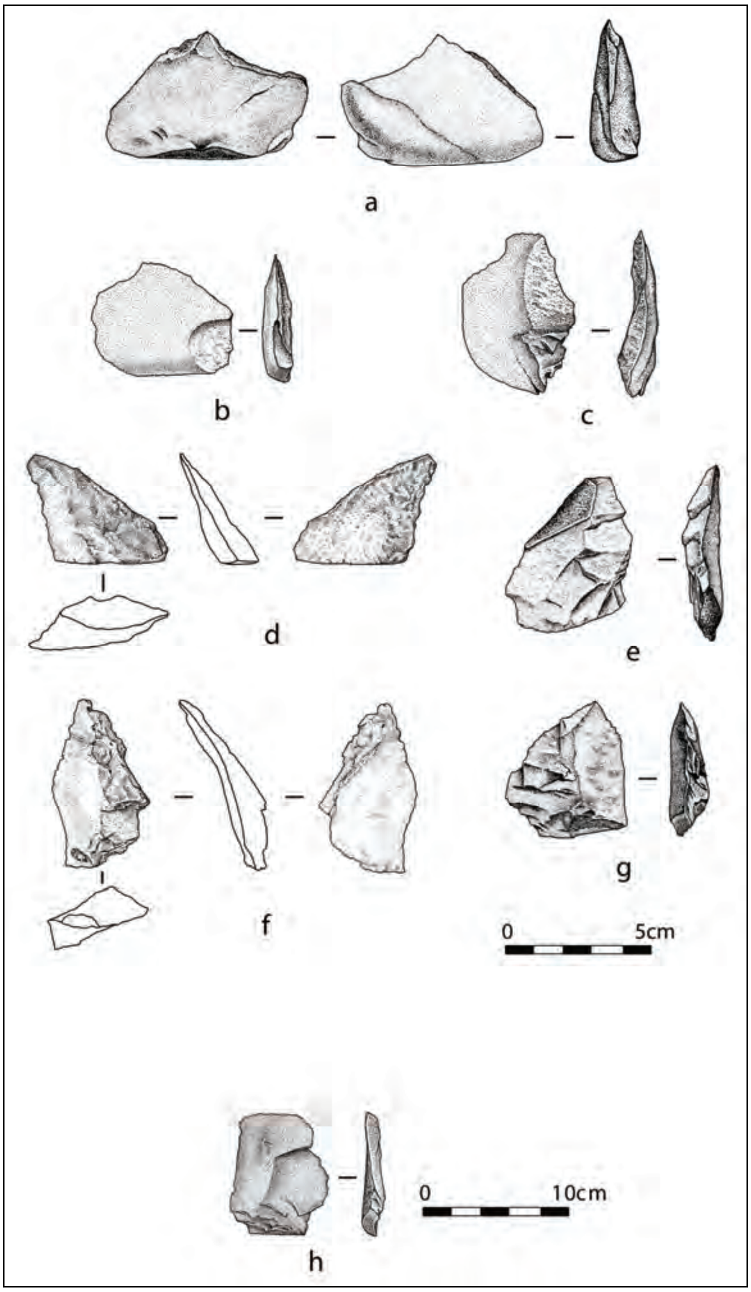

Figure 5: Hoabinhian debitage from Tham Phaa Can
a.–c. decortication flakes;
d.–h. trimming and rejuvenation flakes (White and Gorman 2004).

4.3 Geographic distribution of the Hoabinhian

The currently known geographic distribution of Hoabinhian assemblages is depicted in Figure 3. Despite the poor descriptions of individual assemblages available, archaeologists generally agree that assemblages with the characteristics noted above are widely found in cave/rock shelters and some open air sites across modern MSEA. More than 120 sites are known from northern Vietnam, especially in the Ma River basin, and many sites are found in a broad band extending to the west across northern Laos and northern Thailand into the eastern half of Myanmar (Burma). The Hoabinhian industry also extends south along the Annamite Cordillera of Laos and Vietnam. It is found in western Thailand, southern Thailand, the Malay Peninsula, and the northern half of Sumatra. Known sites are usually in hilly, especially karstic landscapes, although this distribution may reflect a sample bias of archaeological research at cave sites. Hoabinhian lithics have not been found in interior parts of large, relatively flat alluvial basins like the Chao Phraya in central Thailand or major tributaries to the Mekong in northeast Thailand and Cambodia. But the industry is found in upland fringes around these basins in eastern Thailand and northwest Cambodia. This distribution within MSEA may reflect the geomorphological distribution and availability of typical source of raw material for Hoabinhian tools—water worn river cobbles—and their rarity and even absence in large relatively flat alluviated basins.

The outer geographical reaches of the Hoabinhian technological tradition are not entirely clear. The outermost assemblages often co-occur at the same or nearby sites with technologically distinctive lithic industries, which implies that Hoabinhian technology came into contact with other lithic traditions. To the north of the main expression of Hoabinhian, possibly related assemblages have been noted in southern China in Yunnan, Guandong and as far east as Guangxi (Rispoli 2007).

It has been suggested that sites with Hoabinhian lithics can be found as far west as South Asia, often in association with ‘tropical monsoon forests’ along the sub-Himalaya hills. In northeast India, in the Garo hills of Meghalaya, Sharma (1984, 1990) identifies ‘typical Hoabinhian’ with flaked river cobbles of dolerite at sites such as Rongram Alagiri. Mohanty et al. (1997:174) claim that Hoabinian tradition tools have been found in eastern India in the Myurbhanj district of Orissa. Mohanty (1993) notes the unexpected presence of heavy duty tools, principally unifacially flaked dolorite river cobbles, at 39 sites. These implements are in assemblages that are undated but considered ‘Mesolithic’, often dominated by microliths made principally of chert.

In Nepal, a Hoabinhian-like lithic industry dating to earlier than 7500 BP calibrated has been identified at Patu in the Ratu Khola area of eastern Nepal (Corvinus 2007:254, 327). Patu lies in a monsoonal sub-tropical forest belt in the foothills of the Himalayas. Tools are generally unifacially flaked, flattened river cobbles of quartzite, but include some regionally distinctive elements (Corvinus 2007:336–9). The assemblage is more than 95% waste flakes, usually with cortical platforms, and includes typical ‘rejuvenation’ flakes as described by White and Gorman (2004). The heavy duty component of the Patu assemblage is considered quite different from most other contemporaneous South Asian subcontinent and western Nepalese assemblages (Corvinus 2007:285), which tend toward a microlithic tradition. Based on extensive experimentation and observations of gloss, the steep-edged implements are considered suitable for working wood and bamboo (Corvinus 2007). Even further west, Gaillard et al. (2011) suggest that a Hoabinhian-related cobble-based industry can be found in a monsoon forest belt along the southern fringes of the Himalayas in the western Siwaliks.

To the south, shell midden sites with Hoabinhian tools are known along the northwest coast of Sumatra. The cave site Togi Naruwa, on the Sumatran island of Nias (Forestier et al. 2005), is one of the southernmost sites with typical sumatraliths in deposits dating to around 8600 BP (uncalibrated). The Sumatran Hoabinhian is the clearest case for the occurrence of this lithic tradition in island Southeast Asia, and transmission of this technology to the island may have occurred while the Sumatran/Malay Peninsula land bridge still existed, or the Straits of Malacca were still an easily traversed estuarine landscape. Hoabinhian technology has also been claimed for southeast Australia, New Guinea and Japan (Bowdler 2006, 2008; Matthews 1966), but these possibilities would have involved long distance sea-faring and will not be considered here.

4.4 Dating the Hoabinhian

Based on radiocarbon dates from many sites, the Hoabinhian is commonly dated to the terminal Pleistocene and early Holocene. However, how early it appeared is unclear, in part due to the aforementioned lack of commonly employed standards for the description of MSEA stone age assemblages. There is a tendency to lump together all flake and core assemblages dating from pre-LGM to terminal Pleistocene as Hoabinhian, even if no typical sumatraliths are noted.

Nevertheless, Hoabinhian technology appears to have emerged out of MSEA's pre-LGM more generalised flake and core lithic traditions. In Vietnam, an intermediary tradition called *Son Vi* is dated from the LGM to the end of the Pleistocene, but Son Vi as a distinct entity is not recognised outside of northern Vietnam. The interface between a more generalised flake and core tradition and the more focused and systematic lithic tradition emphasizing unifacially and circumferentially flaked ovoid river cobbles is an important issue to be resolved by regional archaeologists. Clarification of this issue is also important for documenting the transmission of the Hoabinhian technology across MSEA as well as to peripheral areas to the north and west.

4.5 Some suggestions on cultural configurations of the Hoabinhian

The discussion of the Hoabinhian above portrays it as a distinct, enduring, lithic technological tradition with roughly definable spatial and temporal ranges, even if the edges in time and space for this tradition are still fuzzy. We can say from the environmental discussion above that the lithic tradition appears to have been a technology shared across a wide range of environments, tropical to subtropical, uplands to coastal. Although it emerged during a period of great environmental change in many parts of MSEA, the technology is found both in areas showing such change (e.g., Krabi and Trang provinces in southern Thailand) and those that are environmentally more stable (Phayao/Maehongson, Thailand). It is found in sites with differing fauna, at sites of different altitudes, latitudes, and habitats, and in both open air (including shell midden) and cave/rock shelter sites. Some sites may have been seasonally or sporadically occupied, but longer term occupations have been suggested for some locations (Anderson 1997:624). A variety of mobility patterns are in evidence (Rabett and Barker 2010, Shoocongdej 2010). The technology does not seem to have been restricted to particular subsistence or social regimes (in the sense that variation in mobility behavior may correlate with variation in group size, sharing patterns, social investment in delayed-return as opposed to immediate return behaviors, and degree of investment in specific locations in a landscape). In view of the broad expanse over time and space of the Hoabinhian technology, most archaeologists do not consider the Hoabinhian as a ‘culture’, but rather consider it a ‘techno-complex’ or an ‘industry’ (Gorman 1972; Pookajorn 1990:25; White and Gorman 2004:437). Recently, Rabett et al. (2011) have used the phrase ‘Hoabinhian cultural complex’. Here I will consider it a ‘lithic technological tradition’.

The expansive reach of Hoabinhian technology over great distances and its endurance over thousands of years does deserve explanation. One view might explain the distribution of the technology in terms of migrations of users, and attribute its endurance to backwardness or ‘conservatism’ of its users. While movement of populations using Hoabinhian technology cannot be discounted, neither is migration a necessary cause of the widespread dispersal of the technological tradition. Alternatively, the technological tradition may represent an easily learned manufacturing process on a natural resource (river cobbles) widely available in a region rich in rivers draining uplands. A product that is quickly made and easily maintained from abundant local resources and is also highly suited for tasks commonly needed could in theory be transmitted via loose interacting networks of practitioners/learners within the zone of abundance of raw materials. The endurance of the Hoabinhian technology probably represents a highly successful and thus sustainable appropriate technology.

But appropriate for what? What were the uses that spanned thousands of kilometers, thousands of years, and so many environmental contexts? The main other common denominator of the Hoabinhian, in addition to being a definable tradition of selecting and unifacially reducing river cobbles, seems to be the presumption that the flaked cobbles were extraction tools mainly used to work ‘wood’, or more specifically bamboo (Bannanurag 1988; Corvinus 2007; Forestier 2003).

Let us postulate that a flaked river cobble/bamboo technological system was the basic Hoabinhian ‘techno-complex’ (Gorman 1972). The flaked river cobble reduction system appears to have been a shared technology over large regions, suggesting that it was an easily learned and readily transmissible technological system. This technological system was used with diverse subsistence strategies in varied environmental zones in Southeast Asia including upland/karstic and coastal (Gorman 1971). Judging from associated floral and faunal remains, Hoabinhian assemblages show no single subsistence or food resource orientation (Pyramarn 1989; Nguyen Viet 2008; Yen 1977). In other words, there is no reason to infer that users of Hoabinhian tools belonged to a single ‘culture’, or had a single cultural configuration. The variety of site placements, lengths of occupations, and variety of resources exploited suggest the existence of numerous different cultures, as one would expect from this large and ecologically diverse area. This cultural diversity has been masked by the widespread uniformity of the lithic tradition. I argue that this uniformity in lithics is due largely to these typical Hoabinhian tools being used to exploit an important resource—bamboo—that was not only widespread throughout the Hoabinhian tool tradition area but was also probably relied upon by all the cultural groups, no matter how diverse they were in other respects.

There are many reasons to suggest that Hoabinhian flaked cobbles are ideally suited to bamboo exploitation. The utility of bamboo is of course not limited to particular subsistence regimes. As an industrial material and edible plant, bamboo is as useful for hunter-gatherers as it is for agriculturalists or fishers. But the implications of the probable bamboo focus of users of Hoabinhian lithic technology have not been fully explored.

4.6 Bamboo, the resource

A postulated focus on bamboo exploitation for the Hoabinhian flaked cobble technological system has implications for: 1) the emergence of 'localised domains of identity' expressed in part via localised bamboo technological traditions, and 2) the effects of focused and intensified bamboo exploitation on regional ecology and subsistence practices. Of course this proposal that Hoabinhian technology was intimately entwined with bamboo exploitation needs more directed research, including application of suitable use-wear studies, experimental studies, and residue analyses to see if the functions of Hoabinhian lithic technology can be empirically identified (Bar-Yosef et al. 2011). In addition, larger implications for systematic exploitation of bamboo need to be considered, if the study of the Hoabinhian period is to advance. Below I briefly propose some implications of the possibility that the Hoabinhian lithic technology fundamentally represents an intensified use of bamboo.

Bamboo has long been recognized as an extremely important resource for Southeast Asian societies. According to Dransfield and Widjaja (1995:15), there are 200 species from 80 genera of bamboo in Southeast Asia, which is considered a main region of bamboo genetic diversity for Asia (Dransfield and Widjaja 1995:16). While bamboos are found in a wide range of habitats from the alluvial plains to mountains, it is most prevalent in low to medium elevations in the tropics and subtropics (elevations comparable to where cobble beds along rivers commonly can be found).

Botanically bamboos are grasses, not trees, which makes their material properties quite different from wood. The most important attributes for human use are that: a) the stems are hollow but rigid so that they cannot be easily bent unless split; thus bamboo lengths can be as strong as a tree stem of similar dimensions but be much lighter in weight; b) the stems or culms have nodes (horizontal partitions) and hollow internodes, whose spacing can be exploited in various ways; for example a single internode with node can be used as a container; c) soft shoots are edible and in some seasons contribute significantly to local human diets; d) from their subterranean rhizomatous base, bamboo grows and regenerates quickly, so that a year-old culm can be used for handicrafts, and a three-year-old culm may be ready for use as building material.

A summary of key bamboo uses (depending on species) include: a) food (shoots and seeds); b) building construction materials, including thick bamboo culms for house posts, split and flattened culms for walls, floors, and roofing; c) containers using individual internodes for storing, transporting, and cooking; d) containers and traps using split lengths woven into baskets for storage and for trapping fish; e) musical instruments; f) hand tools including weapons (blow pipes, projectiles, and sharp long knives; West and Louys 2007); and g) water transportation by strapping several culms together into rafts as the hollow but sealed stems float.

One bamboo type cannot fulfill all these uses. Different bamboo species have different material qualities that affect their performance characteristics as items of material culture. Variations in culm width, length of internodes, fiber length, node and wall thickness, silica content, and other attributes mean that specific bamboos are exploited for specific properties. For example, the large internodes of *Schizostachyum brachycladum* enable it to be used for cooking, but species with long and flexible fibers such as *Bambusa atra* make this bamboo suitable to weave into baskets (Dransfield and Widjaja 1995:21–22). Bar-Yosef et al. (2011) also found that differing qualities of species and clumps affected ease of exploitation.

To harvest and prepare bamboo for use, two main activities are undertaken: *chopping* across the fibrous stem to detach the culm from the clump or rhizome or to detach a section of a culm, and *splitting* when a longitudinal break parallel to the fibers is required (Bar-Yosef et al. 2011). A single split along the length of a culm section enables the culm to be spread out and flattened and used as a surface such as a floor board. Detachment of slender splits can produce bamboo knives or strands that can be plaited.

The main tool needed to exploit bamboo would be a heavy hard implement with a non-brittle working edge that could cut or chop across the fibrous and silica-rich culm. Hoabinhian flaked cobbles appear eminently suitable for such a task. Bar-Yosef et al. (2011) conducted experiments that demonstrated the utility of unifacially-flaked river cobbles for detaching culms from bamboo stands. Longitudinal splits might require an implement with a steeper edge angle but with a suitable weight (or a flake and cobble can be used together; Bar-Yosef et al. 2011) depending on the size of the culm and the desired thinness of the strand, if detaching pliable strands to make plaited artifacts. Although woods, rattans, and other plant products were likely exploited by users of a Hoabinhian toolkit, the modest labor involved in exploiting hollow bamboo stems in comparison to solid trees, the astonishing versatility presented by bamboo compared to other plants such as rattan, and the rapidity by which bamboo regenerates, all suggest that when available, bamboo was more intensively exploited than solid tree wood or other industrial plant resources.

How available was bamboo to users of Hoabinhian technology? Figure 6 shows that Asiatic woody bamboos have a wide modern day distribution from South Asia to southeast China. However, the centre in Asia of greatest bamboo diversity appears to be mainland Southeast Asia (Dransfield and Widjaja 1995:16; Saha and How 2001:659). The coincidence of the region of high bamboo diversity with the main area of Hoabinhian technology is striking, but also raises the possibility of a ‘chicken and egg scenario’. Users of Hoabinhian technology may have intensively exploited many species of wild bamboo that emerged via general processes of allopatric speciation during the fluctuating environmental conditions in Southeast Asia over millions of years. On the other hand, it is also possible that the genetic diversity of bamboo in Southeast Asia could be at least in part a byproduct of long term human use and manipulation of bamboos in this region, perhaps a co-evolutionary phenomenon. Both human and non-human factors demonstrably contributed to bamboo diversification, but we now expand on the former.

4.7 Bamboo and horticulture

There is an aspect of bamboo ecology that has not been discussed by archaeologists but was likely very important to bamboo exploitation, namely that disturbance (human or non-human) stimulates its growth (Dransfield and Widjaja 1995:16). ‘Systematic and regular exploitation increases the production of the bamboo stock’ (Dransfield and Widjaja 1995:41). Natural and anthropogenic habitat disturbance not directly related to bamboo exploitation are likely to have had an unintended consequence of stimulating bamboo expansion. Invasive and fast-growing, some bamboos have strong weedy tendencies, are early colonisers of disturbed forests, or are significant in forest succession sequences (Christanty et al. 1997). Younger rhizomes are particularly productive of new shoots. These inherent expansionary characteristics facilitate bamboo propagation.

Planting a cutting of rhizome stock, a technique termed vegeculture, is considered the easiest bamboo propagation method, quickly producing new young clumps. One year after transplanting a section of bamboo rhizome, new culms appear, in four years a mature clump is established, and the patch can continue to produce culms for decades. Bar-Yosef et al. (2011) furthermore demonstrate that it can be more difficult to extract a culm from older, long-established denser clumps in comparison to clumps with fewer culms. Thus establishing new clumps may save total effort at harvest time by creating new stands with easily harvested culms.

These observations lead to a key point, namely that regular exploitation of bamboo likely entailed horticultural and other delayed-return behaviours. Horticulture involves cultivation of plants as individuals, often in mixed plantings of several species (in contrast to aggregate seed cropping methods which are commonly employed in field monocropping of small-seeded cereals). Horticultural subsistence strategies are common in tropical landscapes, partly because the cultivator can take advantage of both natural and man-made micro-niches to position plants for conditions suitable to individual cultivars. Mixed plots can include both vegeculture and seed propagation. Diversity of environment and diversity of cultivars are both intrinsic to horticultural technology.

One further implication of the ease of regenerating bamboo stock via vegecultural techniques is that it is a very small step to manipulating other plant resources such as yams. A society accustomed to the quick replanting of a bamboo rhizome anticipating return of new shoots in several months would have no difficulty in understanding the usefulness of replanting the top of a harvested yam for an anticipated return in the coming year. We have no direct paleobotanical evidence to support this, but then, no one has systematically looked for it, either. However, some sediment cores do show evidence of forest disturbance during the Hoabinhian period, which has been suggested to indicate some degree of human management of the environment during the early Holocene (e.g., Kealhofer 2002, 2003).

Exploitation of bamboo also has potential implications for exploitation of some fauna. While large mammals were exploited by the users of a Hoabinhian tool kit, only rarely are they prominent in Hoabinhian faunal assemblages (Higham 1977). Small to medium terrestrial fauna are more characteristic of Hoabinhian sites. Straightforward use of bamboo in creating projectiles and simple traps can be postulated.

However, mollusc shells are common in many Hoabinhian deposits and studies indicate that molluscs were likely transported in quantity to sites where they were consumed (e.g., Rabett et al. 2011). While transportation of medium to large fauna (large package resources) does not generally require more than one or two pairs of hands, perhaps a carrying pole and some rattan twine, and a strong back, a focus on small scale resources that are collected in aggregates—for example snails, small fish, and potentially seeds and other plant resources—implies the use of containers to collect and transport the resources to settlements such as caves, as only very small quantities can be transported any distance in one’s hands. The possible importance of plaited bamboo artifacts as containers and traps for at least some users of Hoabinhian lithic technology has implications for emergence of technological styles and cultural diversity in the sense of ‘localised domains of identity’.

Transmission of technological systems over space and time is related to learning frameworks, including social networks and the amount of training needed to acquire the requisite skills. The Hoabinhian flaked river cobble reduction system appears to have been a shared technology over large regions, suggesting that it was an easily learned and readily transmissible technological system. However, once a society relies on plaiting artifacts such as containers, the learning framework and time frame required for practitioners to gain aptitude and fine motor skills needed to consistently construct such artifacts inevitably expands. I suggest that if plaited artifacts that usually have specific functions, design, and performance characteristics—e.g., to trap a particular species of fish in a specific season with specific water conditions, to winnow husked rice, to carry loads of particular weight several kilometers—are made, then the learning curve to replicate reliable artifacts that may be used over the course of months or years takes more time, and requires more direct instruction than the manufacture of simple bamboo knives and projectiles. Knowledgeable practitioners must train apprentices how to select and prepare appropriate raw materials, and how to manufacture durable goods with specific performance characteristics. Apprentices must practice to gain the motor skills needed to reliably reproduce these artifacts. As a corollary basketry learning frameworks tend to result in differentiation in both technological and aesthetic domains: '…it appears to be an established fact that no two populations ever manufacture basketry in precisely the same fashion' (Silvestre 1994:199). Even in ethnographic contexts in Southeast Asia today, basketry and fish trap technology tend to show ethnically distinguishable forms and design characteristics (Baird and Shoemaker 2008:207).

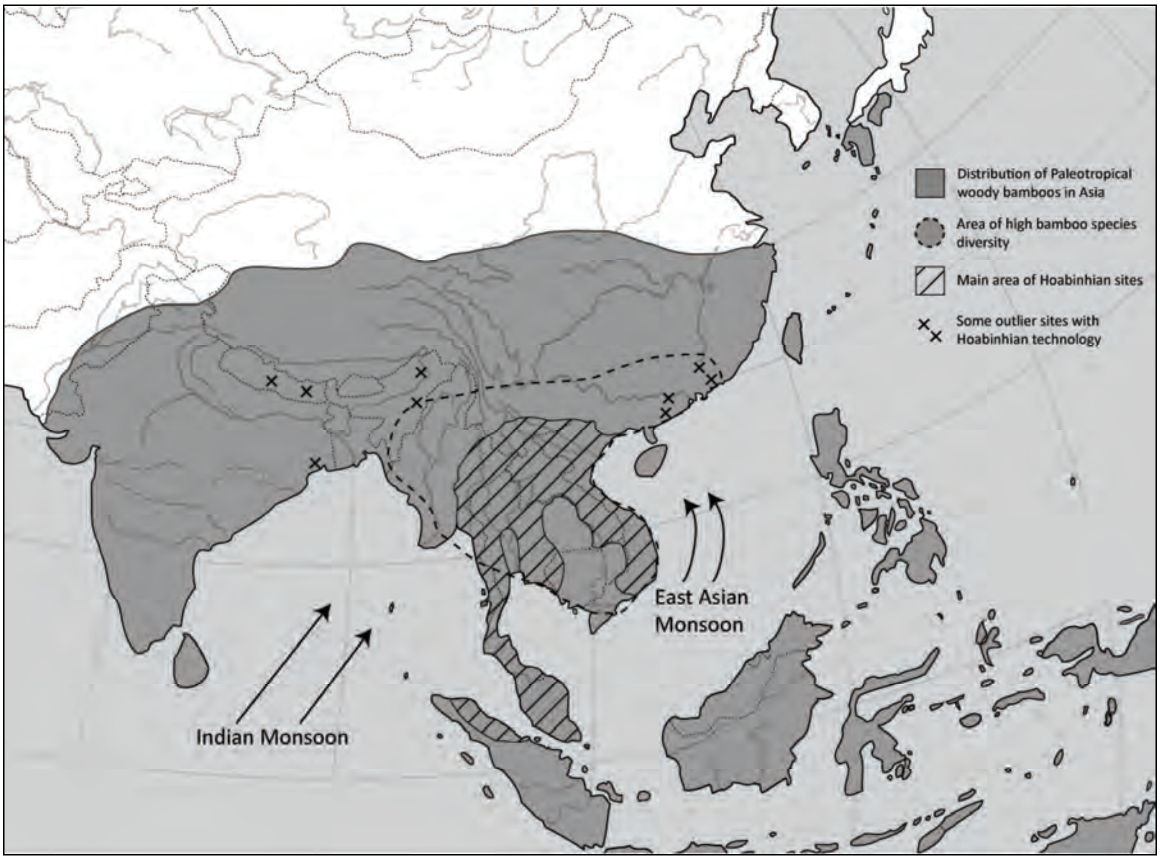

Figure 6: Extent of Hoabinhian technological tradition relative to distribution of Asiatic woody bamboo, area of high bamboo diversity, and summer Asian monsoons. Compiled from map3 in Bamboo Biodiversity http://www.eeob.iastate.edu/research/bamboo/index.html (Saha and Howe 2001).

Societies employing Hoabinhian technology did not necessarily plait bamboo artifacts. Bamboo can be exploited in many ways simply and directly with little stylistic development, technological or decorative. However, once a society commits to a material culture involving plaiting, the level of investment in durable goods suggests a corresponding investment in delayed-return activities. The stage is set for developing an associated learning community with identifying material correlates. Furthermore, the exploitation of specific bamboos for specific plaiting qualities may stimulate exchange among groups with differential access to the raw materials and/or finished artifacts made from specific bamboo materials. The combination of centripetal activities transmitting technological knowledge within a group, with centrifugal activities such as exchange for necessary or exotic materials between groups creates social contexts from which social boundaries emerge (Welsch and Terrell 1998).

The proposal that Hoabinhian technology represents intensified exploitation of bamboo primarily as an industrial product is, at this stage, little more than a suggestion; much research will be needed to further examine this hypothesis with empirical data. And much research is needed to confirm or refute the proposed implications that investment in bamboo material culture contributed to specific learning networks, technological traditions, horticultural activities, and, as a further consequence, constellation and diversification of cultural identities. If these suggestions lead to more thorough examination of the 'Bamboo hypothesis' (Bar-Yosef et al. 2011), the proposals will have accomplished their objective.

5 Post-Hoabinhian Diversity

5.1 The Middle Holocene: the missing millennia

During the middle Holocene (roughly 6000–3500 BP uncalibrated, about 5000–2000 BCE calibrated), the archaeological record in MSEA is particularly sparse. This major gap in archaeological evidence for the region has been called 'the missing millennia' (White and Bouasisengpaseuth 2008:39). Judging from what is known archaeologically about the periods from before 5000 BCE and after 2000 BCE, seminal changes emerged during this gap in the archaeological record. Ceramics appeared in many parts of Southeast Asia; domesticated foodstuffs including millet and rice appeared; tool technologies changed with lithic tools transitioning from predominantly flaked to predominantly ground stone tools. At some point in this period, settlement systems changed focus. Locations of known settlements expanded from primarily karstic upland and estuarine landscapes during the early Holocene to include inland alluvial lowland villages by the late Holocene. Caves declined in importance for habitation (Anderson 1997, 2005). The upland/lowland dichotomy said to characterise Southeast Asian agrarian lifeways may have emerged.

Despite the dearth of archaeological evidence in MSEA for the middle Holocene, the *prima facie* case for cultural diversity strengthens, even though the nature of the transition between societies relying on a Hoabinhian lithic tradition and successor societies is not yet clear. However, a maritime/lakeside adaptation involving sedentary communities appears in some coastal areas, including in northern Vietnam. Da But in the Ma valley (Figure 7) is the best documented of the middle Holocene maritime/lakeside-oriented societies (see review in Nguyen 2005), but some less well known sites in southern Thailand (Srisuchat 1989) with similar dates suggest that this subsistence orientation emerged in other coastal areas of MSEA as well, which is not surprising given the great expansion of coastal habitats with the flooding of the Sunda Shelf. At Da But sites, which date generally c. 5500 BCE cal–3500 BCE cal, evidence for ceramic vessels, ground stone tools, a sedentary lifestyle in villages oriented toward exploiting resources of lakes and coastal swamps, and the practice of residential burial of the deceased suggests that some MSEA communities chose a distinct change in lifeways from earlier in the Holocene (Bui Vinh 1991; Nguyen 2005). It is possible that such an adaptation existed earlier in the Holocene, but marine transgression has prevented archaeologists from finding earlier maritime-oriented sites in MSEA. Nguyen (2005:91), however, describes the emergence of Da But as a local development derivative of the local Hoabinhian.

Figure 7: Holocene sites mentioned in the text.

Evidence for continuation of the Hoabinhian lithic tradition is found in interior cave sites with dates in the middle Holocene in northern and western Thailand (e.g., Pookajorn 1990; Reynolds 1992; White and Gorman 2004). However, deposits from some inland caves/rock shelters dating to the middle Holocene suggest that ceramics and polished stone technologies were appearing in some otherwise Hoabinhian contexts as well. For example, at Banyan Valley Cave, sherds are in clear association with Hoabinhian lithics in deposits dating approximately 4200–2000 BCE cal, and at the end of the sequence edge-grinding appears (Reynolds 1992). The cultural origins of the earliest ceramics and tool grinding technologies found in interior MSEA sites remain to be investigated. It is unclear if these new technologies are appearing due primarily to culture contact via trade with non-Hoabinhian, perhaps settled societies that may have lived in the north, or if population movements are introducing the new technologies. The answers will require identifying and excavating sites dating to the middle Holocene.

The reasons behind an overall decline in archaeological evidence during the middle Holocene as suggested in Marwick (2008c:13) and noted for most of MSEA (White et al. 2004:127, White and Bouasisengpaseuth 2008:39) are not clear. Possibilities include regional population decline or a shift in settlement systems away from caves and rock shelters towards more open air contexts that have so far eluded archaeological research. Archaeological evidence from these 'missing millennia' to resolve this puzzle is surely a priority for the coming decade of archaeological research in MSEA.

5.2 Late Holocene settled societies

By the very end of the middle Holocene in late third millennium BCE, mixed mortuary/occupation sites of settled societies that cultivated plants and raised domestic stock appear in several interior parts of MSEA. Example sites and cultures with late third millennium calibrated dates include Ywa Gon Gyi in the Samon Valley of Myanmar/Burma (Pautreau and Maitay 2009), Non Pa Wai in the Khao Wong Prachan Valley of central Thailand (Natapintu 1991:154; Weber et al. 2010), Ban Kao in west central Thailand (extrapolating from dates in Leong Sau Heng 1991), and Ban Chiang in northeast Thailand (White 2008).

Even though several archaeologists have argued that this late third millennium settlement 'horizon' represents an intrusion of rice agricultural societies ultimately deriving from early farmers in the Yangtze Valley (e.g., Bellwood 2005; Higham 2002; Higham and Higham 2009; Rispoli 2007:287), as the data are analysed in more detail, the picture is not as straightforward and homogeneous as initially expected. Diversity in landscape orientation, material culture, and ceramic and subsistence technologies can be seen in these late third, early second millennium BCE societies.

Those who would claim that a homogeneous group of rice-agriculturalists moved down from southern China into Southeast Asia (View One discussed above) need to address the intrinsic environmental diversity of MSEA when they study the region's prehistoric food producing societies as well as its hunting and gathering societies. The earliest stages of nonindustrial human food production systems tend to be strongly influenced by and to varying degrees mimic and/or manipulate a region's basic natural ecosystem. Given the remarkable amount of inherent environmental diversity in MSEA, it seems unlikely that a single model of hunter-gatherer subsistence strategy or of agrarian change will fit all or most areas of MSEA. Transformations of natural ecosystems by ecologically dissimilar human economies, such as replacing a diverse tropical ecosystem with mono-crop plantations, are costly in terms of labor and high in risk to establish and maintain. Mono-crop field agriculture in the tropics produces populations of species with increased vulnerability to uncontrollable and hence potentially disastrous disease vectors and weather events. In an environmental context as diverse as MSEA, rapid successful incursion from northern Vietnam to the Malay Peninsula of a homogeneous early food production technological system focusing on a single species of cereal seems unlikely. On ecological grounds alone, a realistic expectation of the earliest prehistoric agriculturalists in Southeast Asia is that they did not overinvest in concentrations of a single species but that they hedged their bets with diverse resources and production strategies responding closely to local conditions and contingencies, just as other species do in natural tropical ecosystems. In other words, risk management in pre-industrial tropical ecosystems, man-made or not, almost always involves diversified investment strategies.

Archaeological evidence of this expected diversity can be seen clearly at the sites of Ban Chiang, Non Pa Wai, and Khok Phanom Di. In northern northeast Thailand, rice remains from Ban Chiang dating to calibrated 2289–1978 BCE (White 2008) show the presence of rice-cultivating societies in that region and time. But in central Thailand, Weber et al. (2010) identified foxtail millet (*Setaria italica*) dating to the late third millennium BCE (calibrated 2,470–2,200 BCE) from Non Pa Wai's so-called 'Outlier'.

According to their analysis, rice did not appear in interior central Thailand's Chao Phraya basin until after 1000 BCE. This conclusion meshes well with settlement findings (Eyre 2006, 2011; Mudar 1995; Mudar and Pigott 2003) that pre-metal and bronze age sites of the eastern Chao Phraya basin were preferentially located in upland areas where slopes and soils are not conducive to wet rice cultivation and there is no evidence for ancient terracing. Thus the late third millennium BCE evidence from northeast and central Thailand indicates that at least two distinct and contemporaneous agrarian regimes coexisted in inland Thailand. In coastal Thailand during the late third, early second millennium BCE, another contemporaneous subsistence orientation is evident at the sites of Nong Nor (Higham and Thosarat 1998) and Khok Phanom Di (Higham and Thosarat 2004), which were inhabited by settled societies with a non-agrarian marine adaptation (Higham and Thosarat 2004).

One intriguing aspect of these three areas occupied by settled societies with distinctly different subsistence orientations is that their ceramics appear to share a distinctive ceramic decorative surface treatment, known as the incised and impressed (i&i) style (Rispoli 2007). Pots displaying this decorative style (Figure 8) have a zone, such as a shoulder or pedestal, with incised, usually elaborate designs with impressed infilling (Bellwood 2005:132; Rispoli 2007). The impressions can be applied with a variety of tools and techniques. At Ban Chiang, these impressed designs are made by rocker stamping with a serrated or plain instrument. In other areas, dentate impressions were made by pressing or pricking the surface with a comb, shell edge, or individual stylus (Rispoli 1997). At Ban Non Wat pots with i&i designs are also painted (Higham 2009:205). Despite these differences, there is a common vocabulary and grammar in the range and complexity of the overall composition of the design field. Rispoli (2007:235) expresses the presumption of some that 'these decorative techniques belong to or sprang from a single cultural entity', which until recently had been assumed to be early (neolithic) rice-cultivating societies.

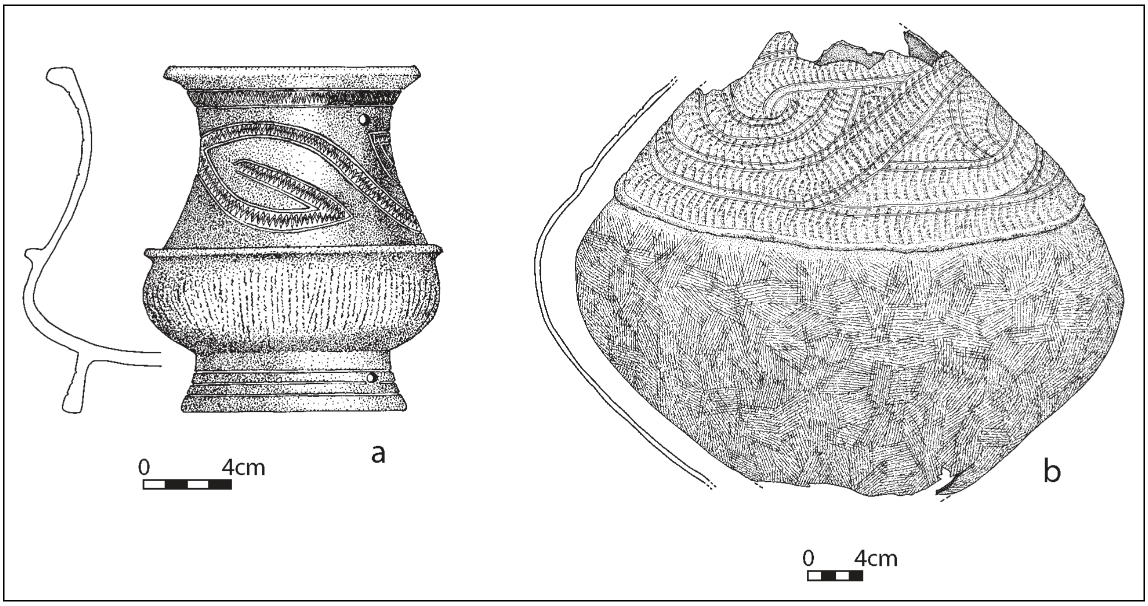

Figure 8: Examples of incised and impressed (i&i) pottery from Ban Chiang, Thailand.

a. Early Period Phase I example dating to about 2100 B.C.E calibrated;
b. Infant burial jar with dentate i&i design from Early Period Phase IIc dating roughly between 2000–1700 BCE calibrated (White 2008).

Current archaeological evidence demonstrates that i&i style was not *ipso facto* related to the spread of rice agriculture, contrary to the proposals of the View One proponents discussed above (Bellwood 2005:132; Higham 2002). As they are examined in detail, the ceramic assemblages if analysed as a whole exhibit clear diversity in morphology and technology. Specialists are at the early stages of studying and publishing technological details of full ceramic assemblages for many of the pertinent sites, yet it is already evident that the forms on which the i&i decorative system is applied vary from subregion to subregion. At Ban Chiang, i&i decoration is most commonly found on large globular or ovoid infant burial jars (Figure 8b) usually formed by coils added to a base slab (Glanzman and Fleming 1985). Within the Ban Chiang levels that contain i&i pottery, most ceramics lack this decorative treatment and many undecorated forms are present. At Ban Non Wat, i&i decoration is commonly found on flaring pedestals of large unrestricted bowls (Higham 2009: 207). Khok Charoen, Non Pa Wai, and Khok Phanom Di each have their own idiosyncratic set of forms with i&i decoration (Higham and Thosarat 1998; Ho 1984; Rispoli 1997).

The intra-site ceramic variability at these late third, early second millennium settlements is also not consistent with expectations of 'neolithic' homogeneity. The best example of the co-existence of i&i vessels with a completely distinct ceramic technological tradition comes from central Thailand at the same site, Non Pa Wai, with millet seeds dated to the late third millennium BC (Rispoli 1997; Weber et al. 2010). At the site of Non Pa Wai was found a vessel forming tradition of impressing clay into large coarsely woven baskets that produce the so-called 'elephant hide' pottery. This localised ceramic tradition co-occurs with i&i, which is found on the same forms as the elephant hide vessels but with cordmarked exteriors (Rispoli 1997).

How to account for the variability in late third, early 2nd millennium BCE ceramic assemblages will be a major challenge for archaeologists and a critical component of any future discussions of MSEA cultural diversity during the prehistoric period. White and Eyre (2011) have proposed that several ceramic subregions in Thailand appear by the bronze age, and it now seems likely that these sub-regions were established in the pre-metal period**.** What social mechanisms led to the establishment of many distinct ceramic traditions in the third millennium BCE? How can we account for a shared decorative technique and aesthetic that appears across technological traditions? It is not yet clear if the appearance of the i&i design system across a wide geographic area represents the spread of people (and potters), the spread of a full technological system, or the sharing of an aesthetic style by many discrete ceramic technological traditions. Understanding the context for the phenomenon will ultimately require study of whole assemblages.

6 Summary and Conclusions

This chapter has reviewed evidence for prehistoric environmental and cultural diversity in MSEA. The region has inherent geographic diversity stemming from its complex geological history, its tropical latitudes, and its late quaternary climate and sea level changes. This inherent environmental diversity sets the stage for cultural diversity reaching back into the late Pleistocene.

How human societies dealt with the complex environmental context can be discerned in variability in settlement and technological choices discernible even in Pleistocene OIS3 sites. It appears that resources exploited ranging from pig to molluscs would have entailed flexible procurement and planning strategies, tailored to the range of habitats in the vicinity of sites. Delayed-return strategies such as would be needed to detoxify certain nuts and yams were employed, as well as more immediate-return, opportunistic encounter hunting.

Habitat-tailoring probably continued in the terminal Pleistocene and early Holocene period when the lithic technology took on a distinctive cast known as the Hoabinhian. Although Hoabinhian lithic assemblages have commonalities across a wide area, the sites from which these assemblages came show diversity and flexibility in subsistence evidence and landscape position. I propose that the florescence and durability of Hoabinhian technology reflects intensified exploitation of bamboo, which has great utility across a wide array of landscapes and subsistence orientations. In addition, as explained above, intensified exploitation of bamboo would likely involve horticultural behaviours to exploit and enhance bamboo's natural proclivity to thrive in disturbed contexts.

If the bamboo-focus of this time frame is empirically confirmed, then I would also propose that there was a consequence for societies that invested in plaited bamboo artefacts, like baskets and fish traps. Because the material properties of bamboo species vary, it is plausible that investment in particular basketry technologies and styles would lead to increased investment in particular geographic areas in order to maintain access to preferred species. Transmission of plaiting technology would require more extended learning periods than needed for flaking river cobbles in the usual Hoabinhian manner. Enduring communities of practice reflecting learning networks for plaiting basketry and traps would likely have formed and regional stylistic variation could have emerged. While the 'Bamboo hypothesis' needs much more research, it is proposed that in some areas, 'localised domains of identity' could have constellated during the Hoabinhian period.

The middle Holocene is a period in MSEA with a dearth of archaeological evidence. Nevertheless, diversity in technology and subsistence orientation is undoubted, with the appearance of settled maritime-oriented societies like Da But. Hoabinhian finds decline, but it is possible that the middle Holocene settlement systems have little archaeological visibility with current archaeological methodologies. Ceramics and polished lithics appear in this time frame, but until archaeologists identify and excavate interior middle Holocene settlements, not much will be understood of this period.

By the end of the middle Holocene, at least three subsistence orientations can be identified: millet cultivation in central Thailand, rice cultivation in northern northeast Thailand, and a maritime orientation in coastal Thailand. Some ceramic vessels from these and other areas of MSEA share, however, a decorative treatment known as i&i style. As assemblages where i&i pottery is represented are studied, it is becoming clear that ceramics of this time range (late third to mid second millennium BCE) are highly diverse in form and technology. Therefore the cultural meaning of this widespread decorative treatment remains unclear. It can no longer be simply claimed that it is tied to the spread of rice agriculture, since it is found with at least three different subsistence regimes.

Marked regionality of ceramic technology and style is indisputable in the metal age (c. 2000 BCE–500 CE). Further archaeological research is needed to explore this phenomenon of ceramic subregions. These subregions are evident across the range of subsistence regimes noted above (dryland millet, probably wetland rice, and maritime). It is proposed that these subregions could coincide with enduring 'localised domains of identity' that involved not only development and transmission of specific technological traditions, but aspects of social life like marriage pools, alliance networks, and subregional ritual systems.

In conclusion, evidence for cultural diversity in MSEA extends far into the prehistoric period, probably mirroring the ecological diversity inherent in the region. Evidence for technological choice is even seen in pre-LGM sites. Diversity in subsistence practices throughout the HG-AG transition argues against models prioritizing homogeneous neolithic waves of advance. As prehistoric technological traditions are more fully defined and studied, the parameters of past cultural diversity will be more convincingly established. The interactions of societies with varying technological styles, such as mobile hunter-gatherers interfacing with settled horticultural communities, is a topic of high priority in the coming decade.

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