Stone Industries of Mainland and Island Southeast Asia

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Abstract and Keywords

Archaeological sites with concentrations of flaked stone dating to the last 5 years, associated with anatomically modern *Homo sapiens*, have been recorded widely across Southeast Asia. Two main types of industries have been documented: those based on knapping the raw stone to produce distinct cores, used for detaching flakes; and those based on flaking the surface of cobbles. Quality of locally available stone underpinned the distinction between the core-based industries, which used fine materials such as chert and obsidian, and the coarser-grained cobble-based industries. This explains the dominance of core-based industries in Island Southeast Asia and cobble-based industries in Mainland Southeast Asia, and the exceptions such as cobble-based industries in northern Sumatra, Niah Caves (Sarawak), and the North Moluccas. Across Southeast Asia, with certain notable exceptions, stone was rarely used for manufacturing distinctive implement types but instead involved the production of impromptu tools for working animal and vegetable material.

Keywords: flaked stone assemblage, ad hoc tool manufacture, core-based industries, cobble-based industries, Island Southeast Asia, Mainland Southeast Asia, Toalean, Hoabinhian, edge-ground tool, polished stone tool

Introduction

WORKED stone is of crucial importance for Southeast Asian (SEA) archaeology because stone is a widely available resource across SEA, it preserves for millions of years under most conditions, and it can retain diagnostic traces of its shaping and use through human handiwork. However, most ad hoc usage and breakage of stone is archaeologically undetectable. Accordingly, the study of SEA stone industries covers site-based concentrations or “assemblages” of knapped stone and/or stone implements with ground and/or polished surfaces. The oldest knapped stone artifacts in SEA date to more than 1.0 million BP (Larick and Ciochon 2015), whereas ground and polished stone implements were predominantly Holocene developments.

During most of the Pleistocene, SEA had a different topography and climate compared with the Holocene (Figure 5.1). Lower sea-levels connected the islands from Borneo to Bali and Sumatra into a subcontinent known as Sundaland, itself connected along a broad shelf to present-day Mainland Southeast Asia (MSEA). The triangle of islands from the Philippines to Lombok and Timor, which can be glossed as “Wallacea” (here including Palawan, for convenience sake), remained disconnected from Sundaland and also from “Sahulland” (New Guinea/Australia) to the southeast. The climate was not only cooler, in tandem with depressed temperatures worldwide, but also generally drier, particularly in those parts of Sundaland that then lay far inland. These topographic and climatic distinctions were particularly marked during the Late Glacial Maximum (LGM) between circa 26.5 and 19 ka (Rabett, 2012).

Archaic hominins had colonized SEA by the Early Pleistocene, as represented by the oldest *Homo erectus* fossils and associated stone artifacts recovered from Java. An ancient capacity for sea crossings is demonstrated by the colonization of Flores before 1.3 million BP by the presumed ancestor of the late Pleistocene species *Homo floresiensis*. (p. 125) When Anatomically Modern Humans (*Homo sapiens*) entered SEA, they would have encountered previously established hominins as far east as the Philippines, Sulawesi, and Timor (Larick and Ciochon 2015). These would have presumably included *H. floresiensis*, whose occupation at the Liang Bua type site has recently been redated to 190-50 ka BP (Sutikna et al. 2016, Tocheri et al. this volume).

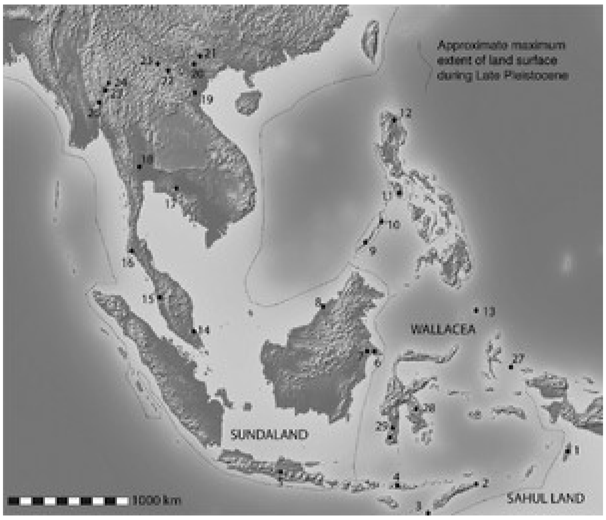

Figure 5.1 Sites and complexes with a Pleistocene component described in the text. 1. Leang Lemdubu, Leang Nabulei Lisa, 2. Jerimalai, Lene Hara, 3. Lua Meko (Rote), 4. Liang Bua, 5. Gua Tabuhan, Gua Braholo, 6. Liang Abu, 7. Kimanis, Lubang Payau, 8. Niah, 9. Tabon, 10. Ille Cave, 11. Bubog, 12. Callao Cave, 13. Liang Sarru, 14. Gua Sagu, 15. Kota Tampan, Bukit Bunuh, Gua Gunung Runtuh, 16. Lang Rongrien, Moh Khiew, 17. Laang Spean,18. Lang Kamnan,19. Con Moong, 20. Son Vi, 21. Nguom, 22. Tam Hang, 23. Ngeubhinh Mouxeu, 24. Spirit Cave, 25.Tham Lod, 26. Padah-lin.

The timing of the entry of *H. sapiens* would have approximated the 75 ka date of the Lake Toba supereruption in what is now Sumatra, leaving open the question as to whether this cataclysmic event impacted heavily on the region's archaic humans and/or had a bottleneck effect on the earliest Asian modern human lineages (Oppenheimer 2014). Intriguingly, the artifacts from the lithic workshop at Kota Tampan, which were covered by Toba ash fall, resemble the "pre-Hoabinhian" assemblages (see what follows) dated to around 40,000 BP and later from other Pleistocene sites in the Thai-Malay Peninsula (Bulbeck 2011). However, lithic technology is not currently viewed as a reliable (p. 126) indicator for distinguishing between archaic hominins and *H. sapiens* (O'Connor and Bulbeck 2011), whose presence by 40,000 BP at the Niah Caves in Borneo (Reynolds et al. 2013) is amply demonstrated by *H. sapiens* fossils and the use of pigments (unrecorded for archaic SEA hominins). For reasons of space, SEA assemblages dating to around 50,000 BP and later, which can reasonably be associated with *H. sapiens*, are the focus of this contribution.

A general caveat is worth noting on the limitations of stone artifacts for cultural interpretation. The propensity of stone for preservation implies that the humans, whose presence is signaled by their lithics, produced a much richer range of material culture, notably from organic materials, which has less often been preserved over long periods of time. Accordingly, stone artifacts may in most cases be inadequate as a basis for the recognition of "archaeological cultures," defined by Fagan (1994: 79) as "consistent patternings of … the material remains of human culture preserved at a specific space and time at several sites."

Mainland Southeast Asia and Sumatra

During the late Pleistocene, Sumatra was connected across the Melaka Strait to the Thai-Malay Peninsula and MSEA, making up the northwestern two-thirds of the SEA subcontinent. Most of the terminal Pleistocene to mid-Holocene lithic assemblages of this region are assigned to an industry labeled the Hoabinhian, named after the Vietnam province of Hoa Binh, where the industry was first described. The Hoabinhian was present by 43,000 BP in Yunnan in southwest China (Ji et al. 2016) prior to its southward extension during a period of around 30,000 years.

The Hoabinhian is characterized by river cobbles (often called "pebbles" in the literature) with overlapping, centripetal flake scars. The hallmark examples were unifacially flaked from one edge or multiple edges, as part of a *chaîne opératoire*, or "reduction sequence," whose ultimate expression involved "sumatraliths" with flake scars covering the face and edges. This flaking technique could also be applied to both faces, resulting in bifacially flaked cobbles, rare in most assemblages but more common than unifacial pieces in some assemblages (Figure 5.2). Numerically speaking, flakes from the cobbles (with a high incidence of cortical striking platforms but a low incidence of retouch), rather than the flaked cobbles, dominate the assemblages (White 2011).

Mainland Thailand, Laos, Cambodia, and Myanmar (Central MSEA)

Recent excavations have recorded a few pre-Hoabinhian assemblages in central MSEA. Excavations over 5 m^2 at the Ngeubhinh Mouxeu rockshelter in Laos recovered a sparse (p. 127) (p. 128) assemblage of nine retouched and other flakes, made of chert, associated with thermoluminescence dates of 56,000 and 45,000 BP (Zeitoun et al. 2012). At Laang Spean cave in Cambodia, Sophady et al. (2015) recovered a small number of (undescribed) artifacts beneath the Hoabinhian layers dating back to 11,000 BP (see what follows) and a level dated to between 26,000 and 71,000 BP. Finally, recent excavations involving Ben Marwick of the late Pleistocene deposits at Padah-lin cave recovered a cobble-based assemblage dominated by bifaces, similar to the later assemblage previously described by U Aung Thaw (see later) except for lacking any typical Hoabinhian forms.

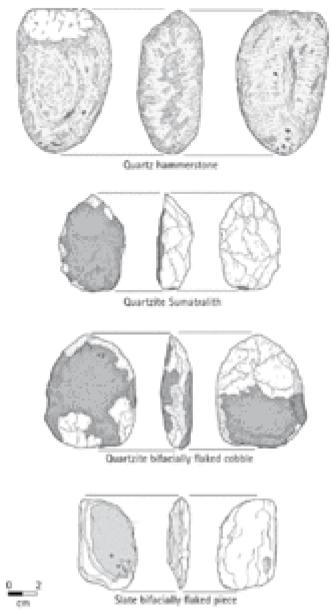

Figure 5.2 Hoabinhian tools from Gua Gunung Runtuh, Peninsular Malaysia, based on original drawings by Valet Bujang (Majid 2013: Figure 1.12).

With a series of radiocarbon and thermoluminescence dates that display general stratigraphic consistency between circa 40,000 and 14,000 BP (Marwick 2013), Tham Lod in northwest Thailand has yielded the oldest MSEA assemblage unambiguously assigned to the Hoabinhian. Cobble-based forms include sumatraliths, partial sumatraliths with incomplete unifacial flaking and usual production on broken cobbles, and other pieces described as choppers from the concentration of flake scars and/or steep splits along one edge. Some retouch of the flakes has been recorded. Over half of the lithics were manufactured from sandstone, probably acquired from the stream near the site, with a smaller proportion made from quartzite (Celiberti et al. 2015).

Lang Kamnan in western Thailand overlaps in its chronology with Tham Lod. The cave has a basal unit dating between circa 30,000 and 11,000 BP and two overlying cultural units that reflect continued occupation until circa 2500 BP (Shoocongdej 2000). Although

Shoocongdej (2000) did not analyze her predominantly quartzite lithics in a manner conducive to classifying them as Hoabinhian, the illustrations of her “cores” reveal flaked cobbles that could be classified as choppers and sumatraliths. The flaked stone industry continued unchanged even after the mid-Holocene appearance of polished stone axes and discs, along with earthenware pottery, a phenomenon also found at several other sites in western and Northwest Thailand (Marwick 2007).

Other central MSEA Hoabinhian lithic assemblages postdate Tham Lod (see also Figure 5.3). These include: Tam Hang in northern Laos, largely quartzite, circa 14,000–<10,000 BP (Patole-Edouamba et al. 2015); Spirit Cave in northwest Thailand, mostly quartzite, circa 12,000–7000 BP (Marwick 2007); Tham Ongbah in western Thailand, circa 11,000–9000 BP (Kamminga 2007); Laang Spean in western Cambodia, mainly hornfels, circa 11,000–5000 BP (Forestier et al. 2015); Khao Talu, Ment, and Heap caves in western Thailand, with cultural layers between circa 11,000 and 2000 BP (Marwick 2007), an interval that would probably cover the undated assemblage on quartzite and finer-grained stone types from nearby Sai Yok cave (Kamminga 2007); Ban Rai in Northwest Thailand, predominantly quartzite, circa 10,000–6000 BP (Marwick 2013); and Steep Cliff Cave and Banyan Valley Cave in Northwest Thailand, respectively 7500–5100 and circa 5300 BP (Marwick 2007). These assemblages show a shift away from the use of sandstone but no consistent differences from Tham Lod in their categories of cobble-based forms. Where differences are apparent, these are often noted as changes over time within the assemblage: for instance, a transition at Tam Hang toward the selection of smaller cobbles for flaking (Patole-Edouamba et al. 2015), and increased use of chert/chalcedony for producing bifacial pieces in the Talu/Ment/Heap sequence (p. 129) (Marwick 2007). Use of the flaked cobbles and/or the larger flakes for working bamboo and other plant material has often been proposed in the literature (White 2011), while Kamminga (2007) even suggests that sumatraliths functioned as axes for ring-barking trees, clearing undergrowth and carpentry.

Figure 5.3 Sites and complexes with a Holocene component described in the text.

Attention should also be paid to the lithics from the Padah-lin Caves in Myanmar. U Aung Thaw (1971) dates the lithics to circa 14,000–7500 BP, albeit without relating specific stratigraphic levels to his “tool” categories, including the polished scraper and pitted cobble (“doughnut” stone) categories which made him characterize the industry as Neolithic as well as Hoabinhian. The illustrated specimens (U Aung Thaw 1969) include examples that would be readily classified as Hoabinhian forms, such as sumatraliths and bifacially flaked cobbles, but also others with a non-Hoabinhian flavor, such as split cobbles and multiplatform cores. Where lithology is provided for the illustrated specimens, it seems to indicate increased use of finer-grained stone for more intensive flaking: for example, about half of the bifacially flaked cobbles were made on igneous rock and about half of the retouched flakes and the sumatraliths on quartzite, whereas sandstone was used for about half of the split cobbles and unifacial choppers, and granite for half of the sparsely end-flaked cobbles (Table 5.1).

(p. 130)

Table 5.1 Lithology of Padah-lin Cave lithics illustrated in U Aung Thaw (1969) related to artifact category

Category	Granite	Sandstone	Siltstone	Quartzite	Limestone	Igneous	Fossil wood	Chert	Total
Sparsely end-flaked cobbles *	8	5	2	1	–	–	–	–	16
Split cobbles	–	9	3	–	2	–	–	–	14
Unifacial cobble choppers	1	5	3	1	–	2	–	–	12
Short axes	1	1	1	2	2	–	–	–	7
Sumatraliths	–	2	1	3	1	–	–	–	7

Bifacially flaked cobbles	–	1	–	6	3	9	1	–	20
Multi-platform cores	–	–	1	1	1	–	–	1	4
Retouched flakes	–	4	2	10	2	2	–	–	20
Polished cobble fragments	–	–	–	1	–	–	–	–	1
Pitted cobbles (doughnut stones)	–	2	5	–	–	–	–	–	7
Total	10	29	18	25	11	13	1	1	108

(*) Includes suspected hammerstones and pestles.

Vietnam

The earliest Vietnam assemblage, the so-called Nguomian, is dated only by its age in excess of 27,000 BP. It is distinguished from the Hoabinhian by its greater frequency of bipolar and multiplatform cores over flaked cobbles, and its high frequency of small retouched flake tools including points, scrapers and knives (Rabett 2012), as well as the Levallois elements with affinities with the Middle Palaeolithic of India for the oldest Nguomian artifacts (Anisyutkin and Timofeyev 2006).

There was a subsequent changeover to cobble-based lithics, traditionally assigned to a chronological sequence of “Sonvian,” “Hoabinhian,” and “Bacsonian” cultural expressions. The proposed markers of these stages (Higham 1989) are edge-flaked unifaces during the Sonvian, sumatraliths and bifacially flaked cobbles with occasional edge-grinding during the Hoabinhian, and increased use of grinding technology (p. 131) including the production of partially polished axes during the Bacsonian. However, as further sites have been excavated and additional Carbon-14 dates obtained, the distinction between these cultural expressions, even as chronologically overlapping facies (Higham 1989), has continued to break down. Instead, the North Vietnam Hoabinhian is best viewed as involving a range of industries dating between circa 27,000 and 8500 BP with variable working of the cobbles and use/retouch of the flakes as part of the site-based activities undertaken in exploiting the wider landscape (Rabett 2012).

Coarse pottery is associated with some Bacsonian sites, and becomes abundant with culturally distinctive vessel forms in North Vietnam’s mid-Holocene open-air sites. The Quynh Van culture sites, despite dating to the mid to late Holocene, display continuation of the tradition of flaked cobble-based lithics, whereas the Da But and Cai Beo culture sites include lithics with a clear emphasis on smoothly ground faces, classified as axes, chisels, net-sinkers, and so forth (Nguyen 2004). Further to the south, in central Vietnam, the Bau Du open-air sand mound produced an aceramic Hoabinhian cobble industry dated to around 5000 BP including sumatraliths, short axes, end choppers, bifacially flaked tools, and mortars and pestles (Ha Van Tan 1997).

Thai-Malay Peninsula and Sumatra

In the Thai-Malay Peninsula, flaked cobbles shared place with single- and multiplatform cores as the basis for all of the assemblages predating the LGM and some of the assemblages dating to as recently as the mid-Holocene, as described in what follows. Thus, the transition to fully Hoabinhian industries was chronologically delayed compared with North Vietnam. The assemblages from Sumatra, all dated to the Holocene, include non-Hoabinhian assemblages as well as others with a Hoabinhian flavor.

The Pleistocene sites in the Thai-Malay Peninsula include the open-air site of Bukit Bunuh, dated to around 40,000 BP, whose lithics include some multiplatform cores as well as flakes and flaked cobbles. The Lang Rongrien cave has a small, core-based assemblage at its lowest level dated to about 42,000–32,000 BP, and a diverse assemblage including cores and flaked cobbles dated to about 11,000–9,000 BP. The latter description also broadly applies to the assemblages in the Moh Khiew cave in levels successively dated (older to younger) in excess of 31,000 BP, in excess of 13,000 BP, and circa 13,000 –9,000 and 9,000–5,000 BP. The oldest assemblage with flaked cobbles but lacking cores is basal Gua Sagu (c. 17–15,000 BP), a pattern continued into the Holocene levels. The oldest assemblage with documented sumatraliths is Gua Gunung Runtuh (Figure 5.2), based on its dates on freshwater shell which, after allowing for the inbuilt age in riverine shell from a karstic landscape, would correspond to circa 13,000–8000 BP. A feature of these assemblages is the presence of bifacial flaking on the cobbles with the exceptions of the Moh Khiew and basal Lang Rongrien assemblages (Bulbeck 2011; Carbon-14 calibrations from Rabett 2012).

During the Holocene, Sumatra appears to have followed a cultural trajectory separate from the Thai-Malay Peninsula. The Hoabinhian assemblages of early to middle (p. 132) Holocene age on Sumatra (including Gua Pandan in South Sumatra and Togi Ndrawa on Nias Island) apparently lack bifacially flaked cobbles but include cores and sumatraliths (Bulbeck 2011). A complex of now-destroyed, massive shell middens along Sumatra’s northeast coast, directly across the Melaka Strait from the Peninsula, had produced a variety of “classic” Hoabinhian assemblages, with an emphasis on sumatraliths and choppers compared with the sparse occurrence of bifacially flaked cobbles (Van Heekeren 1972); the only clue to their chronology is a dating of around 8000 BP from the Sukajadi Pasar midden (Rabett 2012). The diversity of Sumatra assemblages was expanded by the availability of obsidian in central Sumatra, present at the Tianko Panjang cave by 10,000–12,000 BP (Rabett 2012), and in South Sumatra, where obsidian artifacts were recovered from the Neolithic levels of Pondok Selabe 1 dated to circa 3000–2000 BP (Spriggs et al. 2011). Flaking of local obsidian nodules (Spriggs et al. 2011) reduced them to microcores, with observations of retouched arrowheads and crescentic (backed) microliths from central Sumatra sites (Bulbeck et al. 2000).

On the Thai part of the Peninsula, the Tham Khao Khi Chan cave produced a mid-Holocene assemblage described as similar to other southern Thailand Hoabinhian assemblages, with debitage flakes and broken cobbles the numerically most common artifact classes, complemented by single-platform and multiplatform cores, choppers, bifacially flaked cobbles, sumatralith-like unifaces and retouched flakes (Reynolds 1989). But in the Malaysian part of the Peninsula, cores were absent throughout the Holocene, whereas unifacially flaked cobbles (often including sumatraliths) and bifacially flaked cobbles were ubiquitous (Bulbeck 2011). Another feature of many of the latter assemblages was the presence of used and stained cobbles, also recorded for the Lang Rongrien and Pleistocene Gua Sagu assemblages (Bulbeck 2003).

Central Island Southeast Asia (Java and Borneo)

During the late Pleistocene, Java and Bali were connected to Borneo to make up the southeastern third of the SEA subcontinent. In the standard discourse on SEA lithics, this region is grouped with Wallacea as showing ISEA continuity of a technology based on the production and reduction of multiplatform cores, though the situation is complicated by the focus on worked cobbles at Niah and finely flaked bifaces in Sabah (O'Connor and Bulbeck 2014).

Java

The lithic assemblages in East Java are conventionally assessed as demonstrating a three-stage chronological sequence starting with the "Tabuhan," covering the late Pleistocene, (p. 133) the "Keplek" spanning the Pleistocene/Holocene junction to the mid-Holocene, and the "Gupuh" dated to around 4000–2000 BP (Simanjuntak 2004). The documented Tabuhan assemblages are sparse and consist predominantly of unretouched flakes, smaller in sites (average maximum dimension of 2–3 cm) where chert was readily available but larger at Gua Braholo (average maximum dimension of 5 cm), where limestone was mainly used (Simanjuntak et al. 2015). The Keplek assemblages are characterized by a higher frequency of flake retouch, as for instance at the eponymous Song Keplek site with its variety of scrapers and pieces described as knives, perforators, and convergently retouched prisms (Forestier 2007). This lithic industry based on the use of flakes from multiplatform cores continued during the Gupuh period, associated with a light presence of potsherds and polished adzes (Simanjuntak 2004).

The diversity of Java flaked lithics is augmented by surface finds, including bifacially flaked points—some with a hollowed base—found in East Java in association with polished adzes, and finely flaked obsidian implements including projectile points and (backed) microliths from the Bandung area of West Java (Forestier 2007). Flaked obsidian artifacts in stratified contexts include early Holocene specimens at Gua Pawon, West Java, from sources near Bandung, and unsourced, pre-Neolithic specimens at Sodong, East Java (Spriggs et al. 2011).

Niah Cave West Mouth

The lithics from Niah are assigned to three pre-Neolithic intervals between 50,000 and 4500 BP and to the Neolithic circa 4000–2000 BP. The lithics were present at low concentrations but are of interest for their evidence of pre-Neolithic grinding technology.

The assemblage dated to between circa 50,000 and 35,000 BP consists of two small, single-platform quartz cores, an irregular limestone core, and 46 flake/shatter pieces of hard shale, limestone, chert, and jasper. Apart from the chert and jasper, the assemblage would appear to represent expedient use of locally available stone for direct percussion within or near Niah. None of the artifacts exhibit evidence of retouch, but microscopic study of the edges revealed traces of tree resin and bird feathers, and use-wear consistent with working hard and soft plant materials and possibly bone. Similar signs of use were also observed on unflaked fragments of quartzite, limestone, and metamorphic rock (Reynolds et al. 2013).

An expedient, unstructured stone industry is also reflected in the lithics dated to between circa 35,000 and 11,500 BP, but with more of an emphasis on shatter fragments than flakes or flake fragments, and the addition of flat, modified pieces referred to as plaquettes (Barton et al. 2013). Ground-stone tools may have appeared as early as 17,000 BP but increased markedly in frequency between circa 11,500 and 4000 BP. Metamorphic and igneous cobbles were converted into pounders and mortars for processing plant material. Preparation of plant foods and other materials was undertaken using ground tools, usually of fine-grained sandstone, which was also used for polishing pebble axes and cobble adzes, and for making hammerstones and amorphous "rubbers." (p. 134) These inferences are based on microscopic analysis which was also applied to a sample of volcanic and quartzite flakes and flake fragments (unretouched) from the same levels, demonstrating their use for working soft and hard materials and crushing mineral oxides (Rabett et al. 2013).

Formally shaped polished adzes, with a quadrangular to lenticular cross-section, and made on dark green to black stone, are dated to after 4000 BP, often associated with burials. Plant residues and traces of mortar use have been observed on the adzes and fragments. Production of quartzite flakes (rarely retouched), sandstone grinders, hammerstones, and mortars continued without interruption into the Neolithic. Microscopic analysis revealed working of siliceous plant matter, hard material, and mineral pigment (Lloyd-Smith et al. 2013).

Sabah

Sabah's late Pleistocene to Holocene lithics have been published for the Tingkayu Basin and two limestone massifs, Baturong (lying inside the Tingkayu Basin) and Madai (just over 10 kilometers to the east), and for the Bukit Tengkorak cave.

Geomorphological studies indicate that the Tingkayu Basin was dammed by a basalt flow between approximately 30,000 BP (after calibration) and 18,000 BP, creating a lake whose plugged exit apparently attracted human habitation, as testified by the Tingkayu 1 and 2 lithic scatters. These scatters are unique in SEA for their formal bifacial reduction sequence executed on quarried stone rather than river cobbles. Thin planks of a distinctive variety of fine "Kuamat" chert—unsourced, and absent from the cave deposits that postdate 18,000 BP—were broken into quadrangular slabs. Hard-hammer knapping resulted in bifacial removal of the cortex from the margins, frequently followed by the soft-hammer removal of further flakes from the initial flake scars. The end products of the reduction sequence were bifaces shaped like leaves or the various phases of the moon, with a frequently thin cross-section and a proportion of cortex covering that varied from absent to dominant (Bellwood 1988a). Many of the illustrated pieces which Bellwood treated as failed biface discards show considerable retouch along their edges, suggesting that they were useful tools, while Bellwood (1988a) himself noted clear signs of scraping, sawing, and ocher staining on four flakes.

Bellwood (1988b) treated all of the Baturong and Madai flaked lithics as conforming to a Bilo-Sarapad tradition, whether they were excavated from layers dated to between circa 18,000 and 7000 BP (accounting for the great majority of these lithics) or in layers dated to after 3000 BP. The Baturong and Madai cave occupants produced similar lithics even though they differed in the varieties of chert they obtained as river cobbles or geological nodules. About 2%–4% of the lithics are cores, including high-backed unidirectional cores and smaller, more reduced cores, both unidirectional and bidirectional. Around 50%–60% were classified as flakes, including a small proportion subclassified as elongated blade-like flakes, while the remainder were classified as undiagnostic shatter. Retouch and use wear were observed for all of these classes but most frequently on the (p. 135) blade-like flakes and least frequently on the shatter. Traces of silica gloss were observed on some of the edges, while two of the flakes had ocher traces.

Bukit Tengkorak yielded flaked lithics without parallel at any other SEA site. One unique aspect was a long history of obsidian importation, beginning at around 6000 BP with obsidian from the unknown source whose obsidian also reached the Talaud Islands (see what follows), continuing into the Neolithic when small quantities of obsidian were also imported from the Talasea source in New Britain, around 3700 km to the east (Spriggs et al. 2011). The second unique aspect was the Neolithic focus on the production of unbacked agate blades including miniature, thin pieces, often retouched, interpreted as drills. There are also mid-Holocene blade industries in Wallacea (see later) but they lack the prismatic focus of the Bukit Tengkorak blades (Bellwood and Koon 1989).

East Kalimantan

Five main lithic assemblages have been described from the East Kalimantan hinterland rainforests, together covering the last 24,000 years. They are from the cave sites of Lubang Payau (c. 24,000–5000 BP) and Kimanis (c. 13,000–1000 BP) in the Upper Birang catchment (Arifin 2004), and Liang Abu (c. 20,000–1500 BP), Liang Jon (c. 10,000–2500 BP) and Liang Pemalawan (c. 1000 BP) on the Mangkalihat Peninsula (Grenet et al. 2016). These assemblages are similar in showing the preparation of cores (largely chert, including “flint” from the Mangkalihat Peninsula) for opportunistic reduction through the direct percussion of flakes and other debitage. They also lack any clear sign of technological change until well after the appearance of pottery. In addition, a common feature of the three Mangkalihat assemblages is the notable proportion of the tools (about 10%–20%) with ocher traces, consistent with the recovery of considerable amounts of ocher from the sites’ deposits.

The Upper Birang assemblages (349 analyzed stone artifacts from Lubang Payau and 952 from Kimanis) include no blades or standardized forms, a low proportion of used and/or retouched pieces, and a small number of bipolar cores and flakes. The Kimanis artifacts combine a relatively low proportion of chert (one-third) with a diverse lithology in which the main other components are volcanic rock, calcareous sandstone, and, late in the sequence, quartz. The two grindstones include a terminal Pleistocene example from a quartzite pebble and a mid-Holocene fragment of crystalline limestone with ocher residue (Arifin 2004).

The 3,470 stone artifacts excavated in 2012 from Liang Abu, Mangkalihat Peninsula, are characterized by highly reduced multiplatform cores and a diversity of flakes, some of them elongated. There occurred a noticeable reduction in the size of the stone artifacts over time. Retouched tool types include small numbers of distally pointed tools, notches, denticulates, burins, and side scrapers.

Of the three Mangkalihat assemblages, the 1,338 lithics excavated from Liang Jon in 2007 and 2008 reveal the greatest diversity. Distinctive features include a high proportion showing thermal damage, the quite frequent use of a soft hammerstone for (p. 136) knapping, and grinding and polishing traces on some of the quartzite cobbles. Also, large primary flakes were detached for use as cores from which further flakes (“kombewa blanks”) were detached, accounting for up to 25% of the tool blanks in some Liang Jon layers. These are also present at Liang Abu but are not described for Liang Pemalawan. Retouched tools from Liang Jon include low numbers of notches, denticulates, carinated tools, side scrapers, and a burin.

The 482 Liang Pemalawan stone artifacts are distinguished by the presence of riverine cortex including eight tools from pebble cortical flakes and a quartzite flat pebble. This difference from Liang Abu and Liang Jon probably reflects a greater reliance on cobbles from rivers rather than collected stone nodules (Grenet et al. 2016).

Wallacea (including Palawan and the Aru Islands)

Palawan Island, which lies near the northeast tip of Borneo, is technically part of Sundaland but probably not connected to Borneo during the late Pleistocene. The other islands discussed here would also have required overseas crossings for their colonization by *H. sapiens*. Some were relatively easy targets, such as Sulawesi with its long, partly intervisible coastline running east of East Kalimantan, while some others were tiny, remote specks in the ocean. Finally, the Aru Islands are covered here too, even though they would have been connected to Sahulland during the late Pleistocene.

Philippines

According to Pawlik et al. (2014; see also Rabett 2012), three Philippine technocomplexes have demonstrated Late Pleistocene origins: one from Tabon Cave in southern Palawan, dating from perhaps 40,000 BP; a similar industry from Ille Cave in northern Palawan, dating from about 16,000 BP; and the Peñablanca expedient technology in northern Luzon, with an initial dating of around 31,000 BP. In fact, all three technocomplexes show a similar “expedient” technology in which cores of chert (and also of andesite, in Luzon) were opportunistically knapped to produce sharp-edged flakes, and this technology continued till the mid-Holocene in both Palawan and Luzon (see also Mijares 2002). Used flakes were applied to single tasks and discarded with minimal edge retouch, albeit leaving tell-tale edge polish and scarring, at least after application to hard materials such as bamboo and rattan. The terminal Pleistocene Ille Cave flakes indicate a somewhat broader range of uses, including edge retouch for sustained working on red pigment and resins, and a triangular flake that appears to have been hafted for use as a projectile point (Pawlik et al. 2014).

(p. 137) The terminal Pleistocene Ille Cave assemblage also produced five obsidian flakes, from the same source as the five obsidian flakes from the terminal Pleistocene level at the Bubog 1 site in Mindoro. Similar but not identical obsidian has been sourced to Magcarlan, Luzon, which is the source for most of the obsidian found at varying frequencies in Philippine Holocene assemblages. A possible source for the Ille Cave/Bubog obsidian would be a Sundaland source now drowned by Holocene sea-level rise (Pawlik and Neri 2015).

In the central Philippines, including southernmost Luzon, the mid to late Holocene assemblages of flaked stone include a notable proportion of blades, with some retouch into forms classified as points, borers, knives, burins, and scrapers. Chert was the dominant raw material used, and the size of the blades (and “microblades”) appears to correlate with the size of the chert nodules obtained for working (Bulbeck et al. 2000).

Talaud Islands

The Liang Sarru cave on Salebabu Island indicates a capacity for early *H. sapiens* in ISEA to voyage to very small and remote islands, possibly involving successive colonization and extinction events. The four excavated layers (bottom to top) are dated to around 35,000–32,000 BP; 21,000–18,000 BP; 10,000–8000 BP; and the late Holocene (to judge from the inclusion of potsherds). The same lithic technology is in evidence throughout the sequence although with a modest increase in the proportion of retouched pieces during the Holocene, and a transition from pink to reddish-brown chert. The knappers used mainly chert (80% of the assemblage) and volcanic rock otherwise, choosing water-worn cobbles, which were heated to improve their flaking quality. Cores were reduced to a small size, sometimes to the point of exhaustion, through the detachment of flakes and miscellaneous debitage. Flake retouch resulted in a variety of side scrapers, drills, and other pointed flakes (Ono et al. 2015).

The assemblage described from Liang Tuwo Mane’e by Bellwood (1976), with an estimated time range between circa 6000 and 2000 BP, appears to bridge the gap between the early and late Holocene Liang Sarru assemblages. The earlier Liang Tuwo Mane’e lithics show a predominant use of pink chert (complemented by a single obsidian nodule from an unidentified source) and a high presence (50%) of elongated flakes with parallel sides and arrises (“blades”). The later lithics show a switch to reddish-brown chert and the disappearance of blades. Frequent use of the flakes was evident throughout the sequence but retouch was observed on less than 1% of the tools.

Sulawesi

Chert-based assemblages in southwest Sulawesi dating to around 30,000–20,000 BP have been published in summary form for Leang Bulu Bettue and in detail for Leang Burung 2 and Leang Sakapao 1. The large Leang Burung 2 assemblage (nearly 5,500 (p. 138) pieces) includes a small proportion of cores (around 2%) reduced to multiplatform and bipolar “scalar” cores. Another 5% of the assemblage shows signs of use, including 31 flakes with phytolith gloss at their margins and 52 mildly to intensively retouched flakes, mostly scrapers (Glover 1981). The assemblage from the adjacent Leang Bulu Bettue cave differs in its emphasis on exceptionally well controlled bipolar flaking (Moore et al. 2016). To the north, the Leang Sakapao 1 assemblage (821 pieces) shows a technology based on knapping single-platform cores (around 3% of the assemblage) to produce large to medium-sized flakes for direct application to the task at hand, with minimal edge retouch, but with traces of gloss on two flakes (Bulbeck et al. 2004).

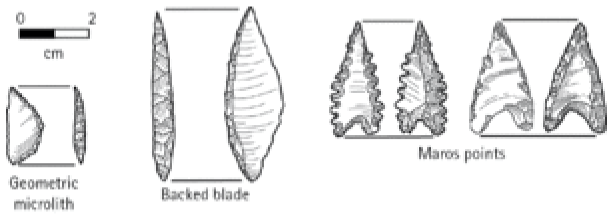

Figure 5.4 Microliths and Maros points from Ulu Leang 1, Sulawesi, redrawn from Glover and Presland (1985: Figures 2 and 3).

The Holocene lithics of southwest Sulawesi are best represented at Ulu Leang 1 with its focus on knapping flakes from multiplatform cores, including scrapers, glossed flakes, and the two “marker” types of the Toalean culture (Figure 5.4)—microliths with bipolar retouch along their back, and Maros points (Glover, 1976). Ethnographic analogy from Australia suggests that the microliths served as inset spear barbs and the Maros points as projectile points. Microliths appear to have been produced from the early to late Holocene, but their distribution may have been restricted to the southern third of the southwest Sulawesi peninsula. Maros points, which are distinguished by their bifacial thinning, denticulate margins, and winged base, appear to have been chronologically restricted to the mid-Holocene but were produced over a larger area including the peninsula’s mid-west coast and Selayar Island lying off the peninsula’s southeast tip. Northeast of the distribution area of Maros points, the Holocene assemblages include some broadly similar tools such as small flakes with a denticulate edge, apparently to assist hafting, and points that lack the bifacial thinning and/or winged base of Maros points. Bone points are another recurring component of southwest Sulawesi Holocene assemblages, both those to the south that can be confidently assigned to the Toalean culture, and the Toalean-related assemblages to the northeast (Bulbeck et al. 2000; Bulbeck 2006).

The open-air site complex of Mallawa appears to capture the transition from a Toalean forager technology to a Neolithic lithic technology. One excavated square produced basalt and chert points and scrapers associated with small numbers of potsherds, while a second excavated square dating from around 3000 BP produced polished axes, axe fragments, and grindstones along with large numbers of potsherds but only a small (p. 139) amount of flaked chert (Bulbeck 2004). A fully Neolithic technology is represented at the Kamassi and Minanga Sipakko sites in West Sulawesi, to the north, with grindstones and a variety of polished stone tools including slate points dating to around 3500–2500 BP, and a marked predominance of nonlocal obsidian over chert for small flaked artifacts (Anggraeni 2012).

Figure 5.5 (a) Debris piece with retouch notch from Square B spit 34 (mid-Holocene), Gua Talimbue, Sulawesi; (b) Flake with retouched edge from Square B spit 60, Gua Talimbue (early Holocene), Sulawesi; (c) Thumbnail scraper from Square E spit 7 (late Holocene), Gua Talimbue, Sulawesi; (d) Flake fragment with silica gloss along the two retouched margins, from Square B spit 43, Gua Talimbue (early Holocene), Sulawesi.

Recently, excavations at Gua Talimbue in Southeast Sulawesi have uncovered a cultural sequence beginning around 18,000 BP and lasting to the late Holocene (Figure 5.5). Of the 27,357 analyzed lithics from Square E, the great majority (83%) represent shatter from the removal of the weathered stone that coated the nodules of chert brought onto the site for flaking. Cores (including bipolar cores and core fragments) and retouched flakes (scrapers) each make up around 2 % of the assemblage. Scraper retouch was generally light, except for a mid to late Holocene type of “thumbnail scraper” with circumferential retouch extending onto the dorsal surface. Three of the retouched flakes also revealed extensive silica gloss (Suryatman et al. 2016).

The site of Paso in North Sulawesi is unique for SEA in presenting an assemblage of obsidian artifacts knapped on site from nodules transported from a nearby source. Dating to around 8000 BP (Rabett 2012), Paso is a midden of freshwater shell with (p. 140) habitation lenses intercalated with dense obsidian debris. The coarse vesicular obsidian available for use was hammered to produce about 60% of the assemblage as chunks, about 40% as recognizable flakes (no blades), and a small remainder of cores, most of them split or incomplete. About 18% of the assemblage show scraper use-wear traces, including the 6% with retouch (Bellwood 1976). Thus, the core-flake technology applied to the Paso obsidian appears to have been basic even though the proportion of pieces with retouch is high by the standards of most SEA assemblages.

Flores

Liang Bua, the renowned type site of *H. floresiensis*, has produced a lengthy sequence with a similar reduction sequence extending back to nearly 200,000 BP (Moore et al. 2009). Large flakes, single-platform cores, multiplatform cores, and anvils/hammerstones were brought into the cave. The large flakes could be directly used, or modified into single-platform cores, bipolar cores, or modified flakes, which themselves could become radial cores and multiplatform cores or retouched used flakes. The uppermost unit at Liang Bua produced the site’s only lithic assemblage (3,255 pieces) that can be confidently assigned to *H. sapiens*. Its distinctive features include the dominance of chert as the used raw material, a high (18%) incidence of artifacts with signs of burning, and the only tools with edge gloss (29 examples). The 11,000–3000 BP chronology stated by Moore et al. (2009) for this assemblage may underestimate its antiquity, in view of the recent recognition that *H. floresiensis* had become extinct long before 11,000 BP (Sutikna et al. 2016).

Van Heekeren (1972) described further Holocene assemblages from the cave sites of Liang Toge, Liang Momer, Liang Panas, Gua Alo, Rundung Cave, Soki Cave, and Mbikong Cliff, and the open-air Aimere site. His focus on the small numbers of retouched flakes and “bladelets,” and the use of fine-grained siliceous stone for a tool kit that lacked identifiable types, makes it difficult to assess whether the reduction sequence described for Liang Bua applies to these sites as well.

Rote and Sawu, Nusatenggara

Mahirta (2003) excavated three cave sites on Rote, at the southwestern tip of Timor, and one cave site on Sawu, around 100 km to the west of Rote. The radiocarbon dates (predominantly on marine shell) date approximately to between 25,000 and 6000 BP for the Rote sites—apart from a single Lua Munggeta charcoal date that calibrates to 956–660 BP—and 6500–5500 BP for Lie Madira (Sawu). Chert was either the only used stone material or, in the case of Lua Munggeta, complemented by a small proportion of igneous rock. The same basic technology was evident at all of the sites, involving a predominance of waste flakes apparently produced on site from multiplatform cores and a small proportion of single-platform cores. The assemblage from each site also included approximately equal numbers of retouched flakes and used flakes without retouch or (p. 141) gloss, complemented by a very small proportion of unmodified glossed flakes. These retouched and used flakes account for 2% or less of the Rote assemblages but about 6% of the Lie Madira assemblage. The latter is also distinctive for its high proportion (41%) of flakes with blade-like proportions, while the Lua Meko (Rote) assemblage stood out for its inclusion of two flakes with retouch apparently designed to facilitate hafting.

Table 5.2 East Timor Holocene flaked stone artifacts as classified by Glover (1986)

Artifact Class	Uai Bobo 2		Lie Siri		Bui Ceri Uato		Uai Bobo 1	
	Count	%	Count	%	Count	%	Count	%
Cores	48	0.8	223	1.4	852	2.2	77	1.0
Trimming flakes	7	0.1	26	0.2	169	0.4	11	0.1
Waste flakes	5340	89.6	15,028	94.5	36,313	91.7	6951	88.5
Glossed flakes	109	1.8	35	0.2	78	0.2	112	1.4
Other used flakes	233	3.9	127	0.8	1,267	3.2	441	5.6
Scrapers (mainly side scrapers)	142	2.4	308	1.9	493	1.2	161	2.0

Other secondar-ily worked pieces	80	1.3	151	0.9	413	1.0	103	1.3
Total	5959	100	15,898	100	39,585	100	7856	100

Timor Leste

Preliminary descriptions are available for early Timor Leste assemblages from Jerimalai, dating back to around 42 ka, and Lene Hara, dating to approximately 30–35 ka. The predominant used material was chert, apparently collected as small nodules, accounting for the highly reduced status of the cores. A range of single-platform, multiplatform, rotated, and discoidal cores, some of them produced from larger flakes, had been knapped mainly through direct percussion complemented by bipolar and anvil-rested reduction. The retouched flakes included scrapers with a frequent presence of notching but no formal types (Clarkson 2014; Balme and O’Connor 2014). A high-silicate obsidian from an unidentified source accounts for a small proportion of the Jerimalai lithics (Spriggs et al. 2011).

Comprehensive descriptions are available for the early to middle Holocene assemblage from Uai Bobo 2, the middle to late Holocene assemblages from Lie Siri and Bui Ceri Uato, and the late Holocene assemblage from Uai Bobo 1 (Glover 1986). The flaked stone was produced mainly from chert, complemented by local pitchstone for small proportions of the Lie Siri and Bui Ceri Uato assemblages (Glover 1986; Spriggs et al. 2011). The analyzed assemblages, which all are large, are consistent in being composed of around 1% cores, 90% waste flakes, 1% glossed flakes, 2% scrapers, and 1% other secondarily worked pieces (Table 5.2). Used flakes without gloss may show the greatest proportional variability between the assemblages, an aspect not addressed by Glover (1986). (p. 142) Glover’s comparisons instead highlighted the unique nature of the Uai Bobo 1 assemblage for its blade cores and ten tanged points, a distinctive type also recovered in small quantities from the Nikiniki 1 cave site in West Timor. The Timor Leste cores could be generally divided between those with a single platform, two opposing platforms, and discoidal cores with multiple platforms. In addition to the flaked lithics, small numbers of pounders, pitted anvil stones, and grindstones, mainly made from basalt, were recovered (Glover 1986).

North Moluccas

The numerically dominant class of lithics excavated from sites in the North Moluccas comprises cooking stones and other manuports of coral and/or volcanic rock, as recorded at Golo Cave (Gebe Island) throughout its sequence from more than 30,000 BP through to recent millennia. Golo also produced cores and flakes of various fine-grained crystalline rock, and two pitted cobbles locally identified as anvils for cracking *Canarium* nuts. Small numbers of these *Canarium* anvils (up to 18 at Tanjung Pinang on Morotai Island) were also recovered from several other cave sites in contexts postdating 5000 BP. The remaining lithics from these other sites, dating back to around 10,000 BP, consist of scantily flaked volcanic cobbles (collected from the beach) and flakes from these cobbles. However, the above observations do not apply to Gua Uattamdi, on Kayoa, which lies off the shore of Halmahera. The Neolithic lithics from this site include four adzes and eight adze chips as well as 25 other flaked pieces dated to between 3500 and 2500 BP (Bellwood et al. 1998).

Aru Islands

The Aru Islands are transitional between ISEA and Sahulland because they lay at the western rim of a plain that connected New Guinea and Australia throughout the late Pleistocene, before the rising sea-levels isolated them into an island bloc (Hope 2005). This sea-level rise evidently affected access to raw stone, because chert was the predominant material recovered from the Pleistocene levels of the Liang Lemdubu and Liang Nabulei Lisa caves, to be replaced by limestone in the Holocene levels. No cores were present in either assemblage, both of which were dominated by small flakes, complemented by some larger flakes and small proportions of other flaked pieces. The 527 stone artifacts recognized for Liang Lemdubu include a small flake with one small retouch scar and three larger flakes (one limestone) with more extensive retouch. The 391 chert flakes include 14% with traces of heat damage, and the chert artifacts exhibit a clear trend toward increased patination with age of the deposit, to the extent that 21 of the 23 specimens in the basal spits (dated to around 28–18,000 BP) had become crumbly (Hiscock 2005).

(p. 143) Discussion

A widespread feature of SEA assemblages is the minimal use of stone for armaments. The few apparent exceptions include the Toalean, restricted to a small part of Sulawesi, and the late Holocene tanged points from Timor Leste. Presumably, spears and, possibly, arrows were manufactured from organic matter, including osseous (bone and tooth) material, for which there is considerable evidence preserved at many SEA sites, and hard plant matter, inferred in the absence of direct archaeological evidence (Rabett 2012). Certainly, working hard plant matter is in evidence for assemblages across SEA where this aspect has been investigated.

The Pleistocene exploitation of chert planks in the Tingkayu Basin, Sabah, underpinned the production of thin bifacial pieces which so far are unique for SEA. Otherwise, wherever chert was readily available locally, it was used in direct hammer percussion to produce single-platform, multiplatform, and other cores from which flakes (including blades, particularly common in a few assemblages) were struck. Most of these assemblages also show use of a small proportion of the flakes for scraping, cutting, or slicing tasks, associated with varying degrees of informal retouch. Residue traces include silica gloss from plant matter and ocher. The general reduction sequence documented for chert was also applied to locally available, vesicular obsidian at Paso in North Sulawesi. Otherwise, where present, obsidian occurred as a highly reduced material and/or a desirable material exchanged across distances of up to 3,700 km.

Industries based on superficially flaked cobbles generally arose where only relatively coarse grains of stone were locally available, especially quartzite and volcanic rock but also sandstone and limestone. These industries also tend to be associated with pitted cobbles, as in the North Moluccas, at Niah and at various Hoabinhian sites, along with the grinding of stone surfaces in the latter two cases. Modification of cobble surfaces through grinding can be understood as a straightforward development from their superficial flaking. This was a separate phenomenon from the typically abrupt appearance of Neolithic polished stone tools, which complemented the ongoing application of the pre-Neolithic lithic technologies.

In general terms, SEA lithic technology can be described as the well-adapted exploitation of local stone resources in a region rich with a variety of plant resources (Rabett 2012). This overview does not rule out the cultural transmission of technological influence across regions, as may explain the apparent late Pleistocene expansion of the Hoabinhian technology from northwest Thailand to North Vietnam and later the Thai-Malay Peninsula, as described earlier. Cultural contact with southwest Sulawesi may also explain the light presence of small Toalean-like tools found in Java (Bulbeck 2008), while the late Holocene appearance of polished stone tools across ISEA in association with red-slipped pottery can be reasonably associated with the dispersal of Austronesian speakers from the Taiwan region (Bellwood 1997). There are occasional instances in SEA prehistory of recognizable archaeological cultures (consistent (p. 144) patternings of human material cultural remains; Fagan 1994) where the stone artifacts played an important role albeit never an exclusive role. These include the Toalean of southern southwest Sulawesi (associated with bone points), the mid-Holocene cultures of North Vietnam (associated with distinctive forms of coarse pottery), and (in a looser sense) the Neolithic of late Holocene ISEA. In general, however, flaked and ground SEA lithics appear to be of limited utility for demarcating cultural boundaries or tracing cultural trajectories, as to be expected in view of their predominant role in adapting to local environmental conditions.

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