New insights on the late Pleistocene–Holocene lithic industry in East Kalimantan (Borneo): The contribution of three rock shelter sites in the karstic area of the Mangkalihat peninsula

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ABSTRACT

This paper aims to present some aspects of the Late Pleistocene–Holocene lithic industry in the inland East Kalimantan region by studying the assemblages found in three rock shelter sites in the karstic area of the Mangkalihat peninsula. This study analyzes these assemblages in their regional techno-complex taking into consideration the environmental components. It focuses on certain aspects of stone flaking technology and the trends in the reduction sequences of the assemblages. Our results show that the reduction sequences, flaking technology and the typology of the blanks and tools, persisted across the Pleistocene/Holocene boundary, as revealed in Liang Abu where the lithic artifacts were found throughout the stratigraphic sequence (over at least 20,000 years). Other excavations in Liang Jon and Liang Pemalawan have confirmed this continuity until the historical eras. In addition, this research emphasizes the potential influence of the environmental and climatic stability (persistence of the rain forest) during at least the last 40,000 years in this region, as well as the inland geographical location, on the continuity of the local stone flaking technology.

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1. Introduction

Southeast Asia (SEA) is a huge geographical ensemble including continental and insular components. Despite numerous works (e.g., Van Heekeren, 1972; Glover, 1973; Bellwood, 1997; Simanjuntak, 1995; Forestier, 2000, 2003, 2007; Forestier et al., 2006b; Zeitoun et al., 2008; Borel, 2010), it remains difficult to propose an exhaustive techno-typological overview of, principally, Homo sapiens’ lithic industry production in this part of the world. The evolution model of lithic industries which is applicable for sites in Western Europe cannot be applied to those in Southeast Asia, as shown by the study of some regional reduction sequences from the Late Pleistocene (Forestier, 2000). The rise in sea level during the Early Holocene gradually shaped the definitive coastlines of the current archipelago (Island South East Asia, i.e., ISEA) creating many islands which could have caused, according to some authors, a diversification of the lithic and bone industrial productions (Forestier and Patole-Edoumba, 2000).

The islands of Sumatra, Java (Forestier et al., 2010), Sulawesi, Timor and Flores, in particular, have many sites containing Late Pleistocene–Holocene lithic assemblages. Regarding the knowledge of the lithic production systems in SEA, Borneo Island looks like a terra incognita with the exception of a few coastal loci in its Malayan northern part, and a few others in the Indonesian part of Kalimantan (West, East and South Kalimantan). Despite a few works on the recent prehistory of Kalimantan for at least a decade, there is a real lack of data concerning the lithic industries.

This new insight aims to provide important data for understanding lithic production systems in this part of Island Southeast Asia (ISEA). This study will first approach the techno-economic
behaviours of certain rainforest prehistoric populations in the karstic inland of East Borneo from Late Pleistocene—Holocene transition up to historical periods.

Our preliminary results raise a few important questions concerning particularly the reasons of the variability of the ISEA lithic productions and their technological continuity throughout the time despite, in certain cases, the succession of two different human species as the transition Homo floresiensis/Homo sapiens (cf. the case of Liang Bua in Flores, Moore et al., 2009) and according to insular geography in its palaeoenvironmental framework. Moreover, our study raises the underlying question of settlement patterns in this area since, at least, the LGM, as shown by some results from our datations, while this region is supposed to have been continually covered by tropical rainforest, since more than 40 ky (Barker et al., 2007; Cranbrook, 2010; Wurster et al., 2010).

Finally, our study results introduce the issue of a neolithization (i.e. related to Austronesian expansion) in the East Kalimantan dense forest area (Fig. 1).

2. Study framework

2.1. Regional archaeological context

In Borneo, the Malayan area has been archaeologically rather well explored for decades as reflected by the Gua Sireh and Lubang Angin excavations (Datan and Bellwood, 1991; Datan, 1993), the Niah caves in Sarawak (Harrison, 1957, 1959; Barker, 2013), the sites in the Madai — Baturong mountains ranges, and Bukit Tengkorak in Sabah (Bellwood, 1984; Bellwood and Koon, 1989). In comparison, the Indonesian area which is the largest part of Borneo, remains relatively unexplored archaeologically, in the context of planned excavations with detailed stratigraphy and reliable dates, with the exception of a very few sites. The main sites from Kalimantan are located: (1) upstream of Kapuas River (West Kalimantan), such as Nanga Balang (Soejojo, 1991); (2) Gua Babi (Widianto, 1997) and Gua Payung (Fajari and Kusmartono, 2013) in the Meratus mountains (Southern Kalimantan); (3) the sites of Kimanis, Liang Gobel and Lubang Payau on the upper Birang river (Arifin, 2004, 2006), in the region of Berau (East Kalimantan); and (4) the sites of the Kebooh caves complex (Jatmiko et al., 2004), Gua Tengkorak (Chazine and Ferrie, 2005), Gua Tekob, Gua Batu Adj, Gua Lungun (Gunadi, 2006), Liang Jon (Chazine and Ferrie, 2005, Chazine and Ferrié, 2008) Liang Abu and Liang Pemalawan (Ricaut et al., 2011, 2013; Plutniak et al., 2014) all located on the Marang and Jelai rivers in the karstic area of the Gunung Marang mountain range in the region of Sangatta, Mangkalihat peninsula (East Kalimantan) (Fig. 2).

2.2. Geological context: the karstic area of Mangkalihat

The Mangkalihat peninsula forms the extreme eastern point of Kalimantan (Indonesian part of Borneo). It faces Sulawesi and marks the northern end of the Makassar Strait at the entrance of the Celebes Sea. It marks the northern limit of the large sedimentary basin of Kutai. Geologically, it is essentially a blend of cenozoic (paleogene and neogene) sedimentary formations from marine and volcanic origin, dating from the Eocene (Muara Wahu region in the western part), the Oligocene (the central karstic area), to the Miocene (the coastal border of the peninsula; Wilson et al., 1999; Wilson and Moss, 1999; Cloke et al., 1999). The karstic area itself belongs to an oligocene sequence limited in its western part by sedimentary formations, a combination of igneous rocks, various metamorphic rocks and cherts from the Mesozoic Cretaceous and Cenozoic Paleocene periods (Moss and Chambers, 1999). In this context, Mangkalihat has diverse geological, sedimentary, volcanic and metamorphic features which offer a large choice of knappable raw material (Fig. 3).

2.3. Archaeological fieldwork in three sites: a brief historical introduction

In 1988 a French speleological exploration, conducted by Fage (1989, 1994) and Fage et al. (2010), discovered prehistoric rock art in the catchment area of the Marang and Jelai rivers (on the western piedmont plain of the Gunung Marang Mountains). In 1992, a French archaeological mission in this area, conducted by J.M. Chazine, explored systematically a series of caves and rock shelters, some with wall paintings (Chazine, 1995). For eighteen years (1992 until 2010), J. M. Chazine conducted archaeological surveys site explorations and excavations in the Gunung Marang karstic area. Since 2011, archaeological fieldwork has been conducted in the framework of a scientific French mission called Archaeological French Mission in Borneo (MAFBO) under the responsibility of F.X. Ricaut. These studies revealed the significant potential of prehistoric archaeology in the karstic area of the Mangkalihat peninsula. Many sites are prehistoric human settlements containing pottery,
faunal and lithic remains, potentially dating from the Holocene. Due to the extensive archaeological work we have undertaken at some of these sites, such as Liang Jon (2003–2008), Liang Abu (2009 and 2012) and Liang Pemalawan (2013), the lithic assemblages could be investigated in their stratigraphic context and studied under good conditions. This study presents a detailed analysis of the lithic assemblages in these three sites in Eastern Borneo. A future synthesis could include a regional description of lithic production systems. This study focuses on some local lithic industries in their geological and environmental context.

The three settlements are located in three different river basins that might be considered as three different micro-territories, at least for the supply of knappable raw material, as shown in the following study.

3. The lithic industry: general introduction to the study


This paper aims to propose a synthesis of three representative lithic studies, focusing on variable reliability of deposits and stratigraphies, that were undertaken in Mangkalihat karstic area in the Kutai region.

The archaeological deposits and the study conditions were different; therefore, diagnoses and comparisons between lithic assemblages remain limited. Despite this fact, these complementary studies yielded results sufficiently comparable to generate a detailed description of some Late Pleistocene–Holocene lithic production systems and lithic industry assemblages in this region.

Preliminary laboratory work was conducted during the annual field missions by different archaeologists in charge of lithic studies. Whatever the considered site, the study protocols were homogenized, as far as possible, while the respective first studies were initially conducted by different archaeologists. The representative samples from each site were entered into databases (Liang Jon by M. Grenet in 2007 and 2008, Liang Abu by J. Sarel in 2012 and Liang Pemalawan by M. Grenet et M. R. Fauzi in 2013) for a comprehensive overview of the samples and easy comparison. Samples were similarly analyzed. “Representative samples” are defined as only identifiable artifacts and/or easily readable in a techno-typological manner. Unreadable flaking waste, thermal fragments, chunks and debris smaller than 1 cm were excluded. The proportion of these samples within the different lithic assemblages can vary depending on deposit conditions and the physical state of the artifacts.

Regarding Liang Jon site, we only considered the results of 2007 and 2008 excavations since no previous database was available for the years 2003, 2005 (Test pits excavations S1, S2 and SA, SB). Concerning Liang Abu, only the results of 2012 excavation, including S3, where taken into account in this paper since test pit S3 is a preliminary part of 2012.

The comparison between the three sites was made through measurement, technological, typological and raw material procurement analysis. A precise comparison with other regional sites, like those of Upper Birang, and Meratus Mountains mainly, remains difficult as there is a lack of data describing precisely these lithic industries. However, the points of comparison seem to exist between some Meratus Mountain sites such as Gua Babi where the lithic industry decreases from the bottom to the top of the stratigraphy akin to Liang Abu (Widianto, 1997, Arifin, 2006), and with Kimanis (Upper Birang) where techno-typological characteristics of lithic assemblage is unchanged even with the arrival of earthenware artifacts (Arifin, 2006: 155).
4. Liang Jon rock shelter

4.1. Site description

Liang Jon (N 01°03’52.74", E 117°16’24.36") is a rock shelter located 35 m above the Meteng River, a small tributary on the left bank of the Jelai River (Bengalon River basin). The shelter opens at the foot of the western face of the Gunung Marang massif (recently named Gunung Gergaji by the authors). This shelter is oriented to the west and is well-protected from the tropical rains. Today, it remains a dry location except at its northern end which has a modest karstic drip pan. It extends roughly on a south to north axis for 30 m. A huge elongated rock, detached from the roof, separates the western part of the shelter from a steep slope. Due to this configuration in the shelter a considerable layer of sediment (>3 m thick) has been trapped in the middle part of the site. The width of the shelter varies from 10 m in the southern part, to 6 m in its middle part, to about 4 m in the northern end.

4.2. Fieldwork history

The site of Liang Jon rock shelter was visited for the first time in 2001, and in 2003. The first archaeological fieldwork in Liang Jon was conducted in 2003 by Chazine and Espagne (2003, unpublished). The fieldwork enabled the first study of the local lithic industry assemblages to be conducted. This work was conducted by J. Espagne in the framework of his Master 2 Thesis at the University of Provence (Espagne, 2003, unpublished). Afterwards, the site was excavated in 2005, 2007 and 2008 by J.M. Chazine, providing a rich collection of artifacts (lithic and earthenware).

In 2003 two test pits (S1 and S2) were dug. These excavations delivered many remains from the lithic industry, earthenware potsherds (at the top of the stratigraphic sequence) and faunal remains including many terrestrial gastropod shells. In S2, two fire structures superimposed on each other were uncovered.

The investigation of the site was completed during the 2005 fieldwork campaign by the excavation of two additional test pits on the surface: SA and SB (Chazine and Ferrié, 2008). SA stopped at a depth of 0.60 m as a complete extended burial was found. SB was dug to the depth of 3 m; the bedrock was not reached. Many undefined artifacts were found. At the depth of 2.45/2.60 m datation gave 10,260 ± 60 BP (SacA 13859,14C AMS-charcoal, Gay, 2010).

In 2007 two test pit trenches were excavated following the main axis of the shelter: TA in the southern part of the shelter and TB along the eastern wall. A third trench TC was excavated orthogonally (EW) to the axis of TA and TB, joining respectively their southern and northern ends. All studied artifacts come from these three trenches.

In 2008, an area of 8 m² was delimitated. It was located in the middle part of the shelter (see Fig. 4 under). It was only conducted at a depth of 25 cm. This excavation provided essentially faunal remains, vegetal remains, beads, some bone industry but no lithic artifacts since the settlement was too recent.

4.3. The lithic industry in Liang Jon

Except for certain data from the excavation of test pits S1 and S2 (2003), no further information about the lithic industry in Liang Jon was available from test pits SA and SB (2005). Our study is essentially based on the lithic assemblages collected in test pits TA, TB, TC, excavated in 2007.

About S1 and S2, the stratigraphy could not be determined due to very homogeneous sedimentation at these locations, thus, the excavation of the two test pits was organized in spits. A total of 380 lithic artifacts was found in S1 (293 recorded) spread over a thickness of 160 cm. S2 delivered 378 artifacts in total (199 recorded), spread within a thickness of 155 cm.

### Table 1

<table>
<thead>
<tr>
<th>Trench</th>
<th>Total number of artifacts</th>
<th>Number of recorded artifacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>TA</td>
<td>136</td>
<td>131</td>
</tr>
<tr>
<td>TB</td>
<td>1025</td>
<td>380</td>
</tr>
<tr>
<td>TC</td>
<td>177</td>
<td>69</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1338</strong></td>
<td><strong>582</strong></td>
</tr>
</tbody>
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### Table 2

<table>
<thead>
<tr>
<th>Raw material</th>
<th>Abbreviation</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown flint</td>
<td>BF</td>
<td>214</td>
<td>36.80%</td>
</tr>
<tr>
<td>Grey flint</td>
<td>Gf</td>
<td>184</td>
<td>31.60%</td>
</tr>
<tr>
<td>Limestone</td>
<td>Lim</td>
<td>117</td>
<td>20.10%</td>
</tr>
<tr>
<td>Indeterminate</td>
<td>Indet</td>
<td>25</td>
<td>4.30%</td>
</tr>
<tr>
<td>Quartzitic sandstone</td>
<td>QtzSS</td>
<td>15</td>
<td>2.60%</td>
</tr>
<tr>
<td>Blond flint</td>
<td>Blf</td>
<td>11</td>
<td>1.90%</td>
</tr>
<tr>
<td>Fossil wood</td>
<td>Fos</td>
<td>7</td>
<td>1.20%</td>
</tr>
<tr>
<td>Chacetary</td>
<td>Chac</td>
<td>2</td>
<td>0.30%</td>
</tr>
<tr>
<td>Stripped flint</td>
<td>StF</td>
<td>2</td>
<td>0.30%</td>
</tr>
<tr>
<td>Black flint</td>
<td>BlkF</td>
<td>1</td>
<td>0.20%</td>
</tr>
<tr>
<td>Calcite</td>
<td>Calc</td>
<td>1</td>
<td>0.20%</td>
</tr>
<tr>
<td>Grey-green chert</td>
<td>Gchert</td>
<td>1</td>
<td>0.20%</td>
</tr>
<tr>
<td>Jasper</td>
<td>Jasp</td>
<td>1</td>
<td>0.20%</td>
</tr>
<tr>
<td>Quartz</td>
<td>Qtz</td>
<td>1</td>
<td>0.20%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>582</strong></td>
<td><strong>100.00%</strong></td>
<td></td>
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### Table 3

<table>
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<tr>
<td>Flake</td>
<td>76</td>
<td>76.00%</td>
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<tr>
<td>Block</td>
<td>8</td>
<td>8.00%</td>
</tr>
<tr>
<td>Fragment</td>
<td>8</td>
<td>8.00%</td>
</tr>
<tr>
<td>Core</td>
<td>5</td>
<td>5.00%</td>
</tr>
<tr>
<td>Blade</td>
<td>2</td>
<td>2.00%</td>
</tr>
<tr>
<td>Pebble</td>
<td>1</td>
<td>1.00%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

### Table 4

<table>
<thead>
<tr>
<th>Retouch and use wear type</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use retouch</td>
<td>54</td>
<td>54.0%</td>
</tr>
<tr>
<td>Shaped tool</td>
<td>34</td>
<td>34.0%</td>
</tr>
<tr>
<td>Mixed retouch</td>
<td>9</td>
<td>9.0%</td>
</tr>
<tr>
<td>Polished</td>
<td>3</td>
<td>3.0%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

### Table 5

<table>
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<tr>
<th>Tools type</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use retouch (URT tools)</td>
<td>45</td>
<td>45.0%</td>
</tr>
<tr>
<td>Indeterminate, mixed retouch or composite tools</td>
<td>18</td>
<td>18.0%</td>
</tr>
<tr>
<td>Polishing and grinding tools</td>
<td>10</td>
<td>10.0%</td>
</tr>
<tr>
<td>Notches</td>
<td>7</td>
<td>7.0%</td>
</tr>
<tr>
<td>Retouch on cester angle (RCA tools)</td>
<td>5</td>
<td>5.0%</td>
</tr>
<tr>
<td>Denticulates</td>
<td>4</td>
<td>4.0%</td>
</tr>
<tr>
<td>Tool cores</td>
<td>4</td>
<td>4.0%</td>
</tr>
<tr>
<td>Carenerated tools</td>
<td>3</td>
<td>3.0%</td>
</tr>
<tr>
<td>Side scrapers</td>
<td>2</td>
<td>2.0%</td>
</tr>
<tr>
<td>Burin</td>
<td>1</td>
<td>1.0%</td>
</tr>
<tr>
<td>Backed piece</td>
<td>1</td>
<td>1.0%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
4.3.1. The 2007 excavation (test pit trenches TA, TB and TC)

After an excavation by spit, Trench A delivered, besides deco-rated earthenware, “culinary” faunal remains, bone tools and ornamental items (tubular and circular beads) shaped on bone and other materials a total of 136 lithic artifacts collected throughout three successive stratigraphic units. 131 were recorded.

Most of the southern part of Trench B, at least for a length of 5.50 m until SB, crosses a sedimentary mass, ashy, pulverulent and of considerable thickness (0.50 – 1.0 m). The archaeological items were apparently uniformly scattered into this reworked sedimentary mass making any stratigraphic identification very difficult. Excavation by spits, however, gave some results and some lithic concentrations were determined. Despite these difficult conditions four stratigraphic units were identified in the southern sector of TB. The whole trench B delivered 1025 lithic artifacts (Fig. 5).

In spite of its uniformity the sedimentary context of Trench C is clearly better than that of TB and the stratigraphy is more distinguishable. The stratigraphy corresponds to that of TB with four stratigraphic units. SU3 delivered a few potsherds from red-slipped earthenware in close contact with a stalagmitic flowstone. This flowstone was dated 2665 ± 35 BP (SacA 1931714C AMS to charcoal, Gay, 2010) giving a terminus post quem for SU 3. An amount of 177 lithic artifacts was collected in TC (Fig. 6).

Globally, the lithic assemblage of TA-TB-TC represents 1338 artifacts (TA = 136, TB = 1025, TC = 177). Of all the gathered and identified pieces, 582 (i.e., 43.5%) were recorded as precisely as possible. Only the identifiable and representative artifacts were considered. Unreadable flaking waste, thermal fragments, chunks and debris smaller than 1 cm were excluded (Table 1).

Many pieces were affected by fire damage to different degrees (N = 173, 29.7% of the whole assemblage). There are 54 burnt pieces showing numerous thermal cracks. 119 pieces were less affected by fire action and were characterized as having been heated.
The Liang Jon 2007 excavation delivered numerous of ochre-tinted artifacts. In the recorded lithic assemblage it represents 20.3% (N = 118). But it is impossible to say if this coloration is intentional or the fortuitous result of an activity related to the preparation and/or use of ochre close to, or by means of, these artifacts.

Since the lithic assemblages from TA-TB-TC does not show any noticeable difference, whether it be in a techno-typological point of view or concerning the raw material distribution, it will be considered in this study as a unique batch (the lithic of Liang Jon). Moreover, the recovered lithic industry is mainly concentrated in two levels, SU2 and SU3. SU4, even if recognized in TB and TC was not explored.

4.3.2. The raw material in Liang Jon

The lithic assemblage of Liang Jon shows the use of a high diversity of raw materials. The procurement of these materials appears to be mainly local with a clear dominance of flint (at least five types, N total = 412, 70.8%). Two categories of flint, a brown (BF) and grey flint (GF) dominate the raw materials suite. They compose 68.4% of all the lithic assemblage; 36.8% (N = 214) and 31.6% (N = 184) respectively. Their origin is very probably local. Some other flint and silexoid rocks can be added to this group (silicified fossil wood, chalcedony, grey-green chert, jasper, N total = 25, 4.3%), that is to say 72.7% of the total. This rock family is completed by the presence of limestone (N = 117, 20.1%), followed by some indeterminate raw materials (N = 25, 4.3%, from metamorphic and/or volcanic origin), quartzitic sandstone (N = 15, 2.6%), quartz (N = 1, 0.2%) and calcite (N = 1, 0.2%) (Table 2, Fig. 7).

4.3.3. The artifacts types in Liang Jon

Although there is a clear predominance of flake blanks (including some kombewa flakes) in the lithic production (N = 521, 89.3%), other artifacts types were used as tool blanks. There are a few of blocks (N = 18, 3.1%) made of flint (N = 12), but also of limestone (N = 4), chalcedony (N = 1) and undetermined raw material (N = 1). Blades are observed in low frequency (N = 9, 1.5%). There are 8 cores, mainly shaped on small flint blocks (N = 7, 1.4%). The remaining artifacts are composed of pebbles (N = 6), tablets (N = 4), knapping waste (N = 1), a flint nodule (N = 1) and one indeterminate blank. Together they represent 2.3% of the assemblage (Fig. 8).

4.3.4. The debitage: flakes and blades

Regarding the debitage of 529 blanks, the overwhelming dominance of flakes must be emphasized (N = 521, 98.5%). Blades only represent 1.7% (N = 9) of the total and there is one quartz knapping waste (0.2%) (Fig. 9). The flakes are rather small and the majority does not exceed 30 mm in length and 30 mm in width, with an average of 20.4 mm in length and 20.8 mm in width. On average the thickness of the flakes is around 5.65 mm (Fig. 10).

The blade products are of diverse size and are mainly made of flint (Bl, N = 4, Gf, N = 3) or silexoid rocks (FosW, N = 1), except one blade of limestone (Lim, N = 1). Their presence in the lithic assemblage must be considered as anecdotal, just as the assemblages of Liang Abu and Liang Pemalawan (see below). There is no blade core or blade knapping waste. Two relatively thick blade blanks were used to shape tools. One blade shows cortical remains.

4.3.5. Cortical artifacts

More than one third of the whole lithic assemblage is cortical remains (N = 200, 34.4%). Among these cortical artifacts, mainly composed of flint or silexoid rocks, there is a predominance of primal cortex remains (N = 193, 96.5%), followed by neocortex (N = 5, 2.5%) and pebble cortex remains (N = 2, 1.0%). This
demonstrates that most of the raw material arrived in Liang Jon in the form of small nodules from primary deposits and that the raw material procurement (rolled flintstones) on the river banks remains anecdotal. The few pebbles of quartzitic sandstone identified which are linked to a specialized tool production, testify to a specific acquisition in a particular geological context (Fig. 11).

4.3.6. Flaking technique
Concerning the flaking techniques, the representative sample was reduced to 411 pieces since there were a lot of broken artifacts, fragments and thermal crack blanks that prevented further sorting. After the examination of proximal parts there is a clear dominance of freehand hard hammer stone percussion. Some rare butts and bulbs might suggest the use of an organic hammer like an antler or a strong bone used in direct percussion (Inizan et al., 1995). The traces made by freehand organic percussion can sometimes be confused with those caused by other techniques; therefore, these traces are ambiguous and shall be considered as anecdotal.

4.3.7. Tools
A total of 100 identified blanks show shaping retouch, use retouch or use marks (17.2% of the whole lithic assemblage). The tool blanks are diverse but mainly flakes (N = 76, 76%), blocks (N = 8, 8%), various fragments (N = 8, 8%), cores (N = 5, 5%), blades (N = 2, 2%) and pebble (N = 1, 1%). This selected tool assemblage only concerns pieces with shaping or use marks visible to the naked eye (Table 3).

The tools are shaped on or use different raw materials blanks. There is no particular raw material preference since the tool distribution roughly corresponds to the representativeness of each raw material in Liang Jon. Certain raw materials, however, like quartzitic sandstone (QtzSs) come from pebbles, and show use traces such as grooves or polished surfaces (N = 3). All the QtzSs flakes or fragments collected in Liang Jon (N = 15) have these kinds of traces. This raw material was exploited exclusively for specific uses (e.g., grinding or polishing), even if some flakes, from the breaking or knapping of the original quartzitic tools, were retouched and used.

4.3.8. Typology
The tool blanks sustained different treatments for their use. Most of them (N = 54, 54%) are raw flakes showing use retouch. There are also shaped tools (N = 34, 34%), a few tool blanks showing mixed retouch (shape and use retouch) (N = 9, 9%) and polished tools fragments (N = 3, 3%) (Table 4, Fig. 12).

The complete tool set includes eleven different types of artifacts (N = 11). It can be divided into two main categories: unretouched tools (Perles, 1983; Andreffsky, 1998) or "URT tools", showing only use retouch or use wear, (N = 5, 45 + 10 if including polishing and grinding tools, i.e. 55%, two types) and shaped tools (N = 45, 45%, nine types) (Table 5).

Unretouched tools (or URT tools) are clearly predominant (N = 45) and indicate a common use of raw flakes. URT tools can be distributed into five (4 + 1) categories. Four types include the tools on flakes, chunks or blocks and the fifth type regards the tools on quartzitic pebbles (i.e., grinding and polishing artifacts). Indeterminate tools (composite URT tools) make up 45.5% of the URT tools (N = 25). Among URT tools, the majority are those with proximal use retouch on the caster angle (N = 12, 21.8%), followed by distal use retouch (N = 5, 9.1%), and lateral use retouch (N = 3, 5.5%). Artifacts on quartzitic pebbles (fragments) showing grooves, grinding and polishing traces account for 18.2% (N = 10) of the URT tool series (Table 6, Figs. 13–15).

There is a diversity of shaped tools (N = 45); there is a high frequency of composite tools on flakes, often with use retouch associated with intentional retouch on different locations. Due to the unclear configuration of this typology they were classified as indeterminate (N = 18, 40%). Notches are well-represented with seven pieces (N = 7, 15.6%). RCA tools (retouch on caster angle), so called because of their typological particularity to show intentional retouch and -or use marks on their proximal part (i.e. on the caster angle) are ranked third (N = 5, 11.1%). These peculiar artifacts are discussed below. Also present are denticulates (N = 4, 8.9%) with an
Fig. 13. Liang Jon – Lithic industry – Tools by use retouch (URT tools) and retouch on caster angle (RCA tools). 1 – Proximal notch on caster angle (RCA tool, flint), 2 – Side scraper on lateral dihedral (Flint), 3 – Denticulate on caster angle (RCA tool), 4 – Use wear on caster angle (RCA tool), 5 – Raw flake, 6 – Raw flake with probable use retouch on caster angle, 7 – Composite tool by use retouch, 8 – Proximal notch on caster angle (RCA tool), (Drawings M. Grenet).

Fig. 14. Liang Jon – Lithic industry – RCA tools and URT Tools by use retouch (see attached file).
equal frequency of tool cores (N = 4, 8.9%), careenated tools (N = 3, 6.7%), side scrapers (N = 2, 4.4%) and, finally, one burin (N = 1, 2.2%) and one backed piece (opposite back and cutting edge, N = 1, 2.2%) (Table 7, Figs. 16 and 17).

4.3.9. The lithic of Liang Jon: synthesis and conclusion

Despite the difficulty in distinguishing a robust stratigraphy in Liang Jon due to the intense reworking of the layers in TB and the high uniformity of the sediments in TA and TC (western part), the excavation by spits clearly shows a few concentrations of artifacts and probable successive beddings, at least in TA (corroborated by a date series) and TC (western part). In TB and TC there are two visible stratigraphic units that delivered archaeological remains (SU3 and SU4).

SU3 shows a pronounced dip towards the north and delivered numerous earthenware potsherds associated to lithic artifacts (including polished tool fragments) and faunal bones. SU3 also appears in TC in the western-eastern section; red-slipped and other

Fig. 15. Liang Jon — Lithic industry — RCA Tools and URT tool. On the left, two Liang Jon pieces with use retouch on the caster angle. On the right, an unretouched tool (URT tool) with use retouch on a lateral dihedron. All these artifacts show ochre traces on or nearby the active portion.

Fig. 16. Liang Jon — Lithic industry — Shaped tools: careenated tools and tool cores (see attached file). 1 — Distal notch on a cortical block (flint). 2 — Side scraper on a thick flake (Bf), 3 — Tool core (careenated denticulate, Bf), 4 — Tool core (side scraper on a block core, Bf), 5 — Tool core (careenated notch on a block core, flint), 6 — Notch on an used up core (Gf) (drawings M. Grenet).
earthenware sherds were found at the base, close to TB. A small stalagmitic flowstone massif separated SU3 and SU4. There was no earthenware in SU4 demonstrating a clear stratigraphic difference with SU3. The sediment is homogeneous and compact, and the remains (lithic and bones) are well-preserved and bedded. Unfortunately, this layer could not be explored fully or precisely dated (only one date in TC under the flowstone massif was recorded, 4070 ± 35 BP) (SacA 13860, 14C AMS for charcoal, Gay, 2010). This finding of an ochre-tinted skull is comparable to the Mesolithic burial practices described in Niah (Barker et al., 2011) and might be, even if in a younger context, culturally linked to the neighboring burial (SA test pit) excavated in 2005 and dated to around 5600 BP, i.e. 5539 ± 33 BP (UBA-19256, AMS bioapatite for bone) and 5634 ± 35 BP (UBA-19257, AMS bioapatite for a tooth).

FIG. 17. Liang Jon – Lithic industry – Shaped tools: sidescrapers (see attached file). 1 – Sidescraper (careenated, flint), 2 – Inverse lopsided scraper (flint), 3 – Sidescraper on cortical flake (bifacial retouch, flint), 4 – Lateral notch on pebble flake (bifacial retouch, limestone) (Drawings M. Grenet).

Fig. 18. Liang Abu rock shelter with 2009 test-pits trenches and 2012 planimetric excavation.
Concerning the lithic industry itself there is no significant difference in the composition of lithic artifact assemblages between the stratigraphic units (SU3 and SU4) or between the trenches TA-TB-TC. The debitage is mainly expedient, and aims to produce small sized flake blanks. Raw material procurement strategies appear similar in all the excavated areas and throughout the stratigraphy.

5. Liang Abu rock shelter

5.1. Site description

The Liang Abu rock shelter (01°28’05.9”N, 117°17’16.3”E) is located within the rainforest of a mountainous karstic area. It is located between two different river basins on the Lesan/Kelai and Karangan River catchments (Fig. 2).

Liang Abu shelter is a vast and dry rock shelter facing east. It is around 25 m in maximum length and between 5 and 8 m in width (Ricaut et al., 2011). The rock wall of the shelter stands at a low angle. It contains a few upper cavities and crevices, which are in connection with a still active karstic system. Remains of relatively recent funerary practices (human bones, wood and rattan remains, and few pottery sherds) have been found in these upper cavities (Figs. 18 and 19).

5.2. Fieldwork history

Liang Abu was located and first explored during the archaeological survey carried out in Berau region (on the Lesan, Kelai and Karangan River catchments) in 2009, in the framework of the MAFBO conducted by J. M. Chazine.

Liang Abu was excavated during two field seasons, 2009 and 2012. In 2009, four test pits trenches (S1, S2, S3 and S4) were opened perpendicular to the rock wall (Fig. 18) and excavated to a depth of around 1 m.
A representative sample of lithic industry was collected. This assemblage was the subject of a preliminary study by J. Sarel (Sarel in Ricaut et al., 2012, unpublished). A new excavation campaign was undertaken in 2012 in the framework of the MAFBO conducted by F. X. Ricaut, (Ricaut et al., 2012, 2013, unpublished). In 2012 fieldwork, test pit S3 was re-opened and extended over 6 m². More archaeological material was recovered including lithic industry, beads, shells, faunal remains and pottery sherds. The lithic industry from the other test pit trenches S1, S2 and S4 was analyzed in 2011 by J. Sarel (Sarel in Ricaut et al., 2011, unpublished). As there is no significant difference between the four assemblages, statistically or typo-technologically, the results are not published here. We present the results of the planimetric excavation in 2012 (including test pit trench S3) and more specifically the squares 11E and 12E as they reached bedrock, and thus covered the whole stratigraphy.

5.3. The lithic industry

5.3.1. The lithic assemblage from S3 (2010 study)  
The 2012 study extended the 2010 excavation in this part of the shelter. Test-pit trench S3 was 2 m long and 0.50 wide. Seven layers were identified. The excavation delivered 440 lithic artifacts mostly composed of fragmented pieces, splinters or little flakes not exceeding 20 mm in length. In addition, 138 flakes longer than 20 mm, 24 chunks, seven pebbles or pebble fragments and three flake cores were found. No blade or blade cores were found in this assemblage. Earthenware remains were essentially found in the two upper layers.

Regarding the raw material, a grey-green silicified material was preliminarily classified as “jasper”; it has been subsequently been reclassified as chert following the study of the lithic assemblage from the neighboring site of Liang Pemalawan (see below).

5.3.2. The lithic assemblage from the 2012 excavation

The excavation area delimited between the test pit trenches S2 and S3 that were explored in 2009 allowed a representative sampling of the Liang Abu archaeological deposits. The area had a surface of 6.5 m² (squares 11E, 12E, 12F, 12G, 13E, 13F, and 13G). The stratigraphy is more or less homogeneous showing very few variations. Nineteen stratigraphic units (SU) were recognized.

The abundance of the remains required that some sub-squares were selected (12Eb, 12Fb and 12Gh) for their detailed study.

The bedrock was reached at the maximum depth of 1.70 m in sub-squares 11Ec and 11Ed. This corresponds to western part of test pit trench S3. The substrate was also reached in 12E (subquares a, b) (Fig. 19).

Squares 13E, 13F and 13G were only excavated to 0.20 m. Consequently, the amount of collected artifacts varies considerably depending on the square and stratigraphic units identified.

The general typological study includes the whole assemblage from the excavation of squares 11E, 12E, 12F, 12G, 13E, 13F and 13G. Technological analyzes were only conducted for lithic material found in all stratigraphic layers of squares 11E (subquares c, d), 12E (subquares a, b). All representative artifacts (i.e. except chunks, splinters and little flakes not exceeding 20 mm in length) were studied.

The 2012 excavation yielded 3470 lithic artifacts mainly composed of fragmented pieces, chunks and splinters; these total >70% of the assemblage. The percentage of little flakes not exceeding 20 mm in length (8%) must also be added to this total. Among the artifacts, there is 32 pebbles or pebble fragments, 21 flake cores, 428 flakes longer than 20 mm and 12 blades. No blade cores were found.

The typology list established per stratigraphic unit shows variable concentrations of material within each unit. However, these results must be weighted regarding the excavated volumes that may differ according to the squares and consequently the stratigraphic units. More than 50% of the artifacts collected were found in SU2, while SU12 and SU13 yielded around 8% of the artifacts. By considering the squares and stratigraphic units, there is no significant difference between the lithic assemblages; the types of artifacts, tools and raw material are in the form of pebbles, mainly grey-green chert (36.4%), flint (21.1%), an andesite-type dark grey igneous rock (17.7%), limestone (13%), chert (9.6%) and at lower frequencies quartzose flint (1.1%), calcite (0.6%) and fossilized wood (0.1%) (Table 8, Fig. 20).

5.3.3. The raw material in Liang Abu

For this analysis all the representative lithic material was taken into consideration. The raw materials used for producing the artifacts are various and are practically present throughout the stratigraphic sequence (see Tables 8–12). The most common raw material are in the form of pebbles, mainly grey-green chert (36.4%), flint (21.1%), an andesite-type dark grey igneous rock (17.7%), limestone (13%), chert (9.6%) and at lower frequencies quartzose flint (1.1%), calcite (0.6%) and fossilized wood (0.1%) (Table 8, Fig. 20).
5.3.4.1. The cores. The squares 11E and 12E delivered 13 cores representing 0.9% of the total assemblage; eight other cores came from other squares. The cores are mostly on pebble, but a percentage is on flakes or small blocks. Like other types of product, cores are made of various raw materials, including grey-green chert, flint, quartzose flint, andesite, limestone and diverse chert. The blanks are not standardized and their forms are not pre-determined. The debitage tended to produce flake blanks of diverse morphology. These artifacts are quadrangular, rectangular, oval-shaped, triangular and sometimes trapezoidal. The elongated blanks were mainly produced from the edge of a core or flake. The flakes are of diverse size albeit a rather small size. Blanks exceeding 50 mm in length are rare. Blank size tends to decrease in the upper stratigraphic units (Table 10, Fig. 22). Length – width ratio of the blanks concentrates around an average comprised between 30 mm in length and 25 mm in width (very similar to that of Liang Jon) (Fig. 23). Among the 247 flakes and blades longer than 20 mm in the assemblage, 53% are cortical flakes (N = 131). Among them, 28 are first flakes and 103 show some cortex on the lateral part, distal part or on the upper face; most of these flakes have a cortical butt (N = 43) that represents 32.8% of the cortical flakes assemblage.

5.3.4.3. The tools. Twenty-six blanks exceeding 20 mm in length were used as tool blanks that represented 1.8% of this product class. Many blanks show use wear, continuous or noncontinuous of one or two edges (N = 63) that corresponded to 25.5% of the blanks. In total, 36.8% of blanks longer than 20 mm from squares 11E and 12E were used as or crafted into tools. The set of flake tools is not very diverse. The converging edge flakes and points are well-represented among the tools (N = 8) while the notches, denticulates, burins and side scrapers are rare. The majority of converging edge flakes show an intentional fracture causing the
shape of a point (Fig. 24, 1 and 2; Fig. 26 1–6) that was often thinned by retouch (Fig. 24, 3). The points are not standardized; they vary in thickness and their position on the flake varies from being on the distal, proximal or lateral part, or near the butt.

The lithic assemblage is mainly composed of simple retouched flakes. The retouch is generally thin and sometimes abrupt, concerning the upper face (Fig. 24, 4). Like those already identified at Liang Jon (Grenet in Chazine and Grenet, 2007; Chazine et al., 2008, 2009, unpublished reports), ten flakes show some scars on the butt (on the caster angle) extending to the upper face, and more rarely the lower face (Fig. 24, 5 and 6; Fig. 26, 7 and 8). For convenience and homogeneity in the description of the excavation results for the three sites, we suggested the term “RCA tools” (see above). Two Kombewa blanks found in SU 4 and SU 8 show similar scars. Moreover, three flakes found in the SU 2, 4 and 8 present removal negatives on their lower faces that indicates Kombewa blank production. This type of flake was also observed in the assemblages from the test-pits trenches of 2009 and during archaeological surveys conducted by J.M. Chazine from 1992 to 2001 and studied by Espagne (2003) (Figs. 24–27).

5.3.4.4. Products with ochre traces. Five limestone tablets and fifteen flakes show ochre traces on one or two of their faces. The majority of flakes are grey-green chert or andesite. They are generally retouched or used and were not found in the upper levels (SU1 to 3) but mainly in S8 (8 flakes, 1 limestone tablet) and S10 (4 flakes, 3 limestone tablets). The remaining artifacts are allocated as follows: SU4 (1 flake), SU12 (1 flake, 1 limestone tablet) and SU 15 (1 flake).

5.3.5. The lithic of Liang Abu: synthesis and conclusion

There is no significant difference in the composition of lithic artifacts between the stratigraphic units or between the sub-squares 11E and 12E; the proportions of artifact types, tools and raw materials are essentially the same. The spatial distribution is also relatively similar. The concentrations of lithic products, however, differ according to the stratigraphic unit. As described previously, the stratigraphic units SU 2, SU 3 and SU 4 contains more than half of the lithic artifacts collected during the excavation. In contrast, only a low percentage of lithic pieces were found in the units from SU 14 to SU 19, identified at a depth of between 1.40 m
and 1.70 m. Earthenware is only present in the upper levels (SU 1 and SU 2) although stone flaking modes are invariably throughout the stratigraphic sequence.

The results of the lithic assemblage study from the 2012 excavation highlighted an expedient type debitage aiming to produce almost exclusively flakes, directly usable, retouched or pointed by fracture (retouched or removal).

According to the numerous first flakes or flakes with peripheral cortex residue, it is highly probable that the used raw materials were collected in the form of relatively small-sized pebbles. The pebbles fragments were mostly ends, probably corresponding to first flakes. This may indicate the way the first flakes were struck at the end of the pebbles. The suite of rocks, in the form of pebbles, used in Liang Abu was very similar to those from Liang Pemalawan and generally suggests that raw material was acquired in the same geological context, that is to say in the Lesan River catchment area.

The pebbles showing the technical criteria of natural convexity to be knapped without preparation were chosen. The “potatoid” formed pebble (and its other forms) has been struck freehand with a hard hammer-stone, producing an opening at one of its ends, and the flaking production line uses the present technical criteria. The striking platforms and flaking surfaces are multiple and alternatively exploited.

Several tools are observed. RCA tools and converging edge flakes are the two main components of the tool set. They are associated to retouched flakes, rare end scrapers, side scrapers and denticulates on flake. The converging edge tool is present in the upper levels of Liang Abu (SU 10 to SU 2). It could demonstrate a specialized local activity that continued until a relatively recent period since the tool was present with earthenware in the upper layers. The contribution of further micro-wear analysis is essential in this respect. In addition, as was observed at Liang Jon, there are some ochre traces on certain flakes made from andesite, grey-green chert and limestone tablets. These ochre-tinted flakes are often retouched or used, potentially demonstrating a relation with specific activities.

The lithic artifact assemblages collected in Liang Abu showed a high typo-technological similarity with that gathered on the surface at Liang Pemalawan (and other neighboring sites in the Lesan River basin like Liang Wanat, Liang Ara, Liang Beloyot Atas) during the 2010 survey. These similar debitages are related to knappers aiming to produce a group of particular products.

![Liang Abu - flakes length / width ratio](image)

**Fig. 23.** Squares 11E and 12E. Length/Width ratio of the flakes.

![Liang Abu - Tools (Converging edge flakes, RCA tools)](image)

**Fig. 24.** Liang Abu – Tools: converging edge flakes (1, 2, 3), retouched flake (4) and RCA tools (5, 6) (Drawings J. Sarel).
Fig. 25. Liang Abu — Tools: Shaped tools, RCA tools, used dihedrons (URT tools) (Drawings M. Grenet).

Fig. 26. Liang Abu (photos) — Tools: converging edge flakes and retouched flakes) (photos J. Sarel).
6. Liang Pemalawan rock shelter

6.1. Site description

Liang Pemalawan rock shelter (N1°32’5.84" E117°18’15.67") is a vast shelter facing west-northwest, opening 500 m east of the left bank of the Lesan River (Kelai River catchment) at the foot of a karstic massif belonging to the tertiary Oligocene landforms of the Mangkalihat peninsula. This site is included in the group of the so-called “Merapun caves”, which includes Liang Abu rock shelter (7.5 km due southeast) and others such as Liang Wanat, Liang Ara and Liang Beloyot Atas (Chazine et al., 2009, unpublished).

Liang Pemalawan is an erosive formation of karstic origin which extends on a roughly south–north axis, about 20 m long and 12 m wide (maximum) between the break of the steep slope and the back wall. The wall and overhang have many stalactitic concretions and many crevices have karstic drip pans. Even if today this shelter seems relatively dry, there is important endemic and cyclic karstic activity. The humidity is still significant, as shown by moss and lichen on the wall and rocks of the shelter. The ground is cluttered with diverse-sized collapsed boulders. After observations, it appears that at least three massive collapse events have affected the rock shelter in the past; a series of big tabular blocks lean against the back wall, testifying to a sudden massive cleavage in the wall.

The southern part of the shelter is constituted by a scree slope, oriented northwest and made of metric blocks. The combination of at least two erosion events covered the whole surface of the site with rocks in a dip oriented west-northwest. Further, as testimony to the ancient collapse of the overhang, a huge boulder has rolled down the steep slope to stop a dozen meters below. Its location, away from the shelter on the mid-slope, did not promise good conditions for a sedimentary trap favourable for a defined stratigraphy.

In these conditions, the choices for establishing test pits or excavations were very restricted. They were mainly dictated by the available lacunar areas between the blocks. We were careful to take into account the dripping line, which restricts considerably the inhabitable area, that is to say a robust archeological zone (Fig. 28).
6.2. Fieldwork history

6.2.1. The 2013 excavation

Liang Pemalawan rock shelter was recognised in the 2010 survey conducted by J.M. Chazine and F.X. Ricaut. Many remains, found directly on the ground, were collected during the first visit to Liang Pemalawan, including earthenware potsherds (N = 39) combined with lithic artifacts (N = 15) and faunal remains in abundance. These first results suggested the regular and ancient frequentation of the site, as with Liang Abu, by people wandering in the Lesan River thalweg and living in the karstic massif. The excavation of Liang Pemalawan was planned after this archaeological survey. Fieldwork in Liang Pemalawan lasted for ten days during June 2013.

After the general squaring of the site, two areas were selected for planimetric excavations (3 m², C7, D7 and E7) including a first test pit (TP1). Due to the poor archaeological results of these field explorations, two more test pits (TP2 and TP3) were dug (Fig. 29).

6.2.2. Area 1 – Planimetric excavation and test pit 1 (TP1): squares C7, D7 and E7

The planimetric excavations in squares C7, D7 and E7 were conducted by successive spits of 5 cm in thickness. The archaeological level was reached immediately under a thin, barren pulverulent layer (2–5 cm). This layer had very scattered remains composed of lithic artifacts and animal bones, often fragmented and sometimes burnt. This first discovery led to the decision to excavate by stratigraphic unit, the first unit was named SU1. The soil stripping revealed some traces of fireplaces in E7; the presence of some charcoal, ash, and burnt bones. The excavation was continued according to the sub-squares. The fresh fracture of some faunal remains and their great disorganization in pulverulent and instable sediment argue for a reworking of SU1. Therefore, a test pit (TP1) was dug in C7 to check the stratigraphic conditions of the deposits (Fig. 30).

This first test pit showed the continuity of SU1 until two-thirds into C7 towards the west and the steep slope break. This continuity is interrupted by significant bioturbation that crosses the square on a north–south axis. Beyond this perturbation, SU1 makes contact with a zone of orangey and compact clay. SU1 does not exceed 15 cm in thickness in square C7.

The clay formation is indurated just under the overhang limit (i.e., the dripping limit). Compare with SU1, the clay sedimentary unit changes significantly in texture; so it was named SU2. This sedimentary unit resembles a bulge with a 40 cm thickness (see Fig. Nr 39 above). It also contains some lithic, earthenware and bone remains similar to those found in SU1. It can be argued that this formation results from a significant alteration phenomenon at the dripping limit. The scree is reached immediately under SU1 (in D7 and E7) and SU2 (in C7).

The mass of fallen rocks was named SU3. This level was excavated for more than 50 cm in depth; it was observed to be barren. As not to anticipate the presence of another archaeological level under SU3, there is currently only three stratigraphic units in area 1 and only two (SU1 and SU3) in the other test pits (TP2 and TP3).

The sieving of the reworked sediments and the stripping of the sub-squares of test pits TP2 and TP3 yielded a few remains: lithics,
earthenware and faunal bones, all in SU1. In TP2 a small fireplace was uncovered and two charcoal pieces, in good condition, were removed for 14C datations. A fire structure was established directly on US3 (scree barren level).

6.3. The lithic industry of Liang Pemalawan

The lithic assemblage at Liang Pemalawan is not abundant: a total of 482 artifacts was collected. A few artifacts from the sieving of reworked areas (surface, bioturbations) were counted but not recorded in the lithic database (N = 390, see Table 18). These artifacts were collected by batch. A representative sample of 92 coordinate artifacts, coming from SU1 exclusively, was recorded and studied (Table 11).

6.3.1. The studied assemblage

The majority of the lithic assemblage from Liang Pemalawan come from area 1, and represents 84.8% of the total recorded (C7/TP1 = 70.7%, D7 = 8.7%, E7 = 5.4%). The lithic artifacts found in TP2 and TP3 were 14.1% of the assemblage (TP2 = 9.8% and TP3 = 4.3%). One tool was found on the surface of D8: a sandstone block showing traces of usage. From a typo-technological point of view, the general distribution of blank types was marked by the very high frequency of the flakes (N = 80, 86.95%) and among these, flakes on pebbles with cortical remains (N = 61, 66.3%), and the lower percentage of ordinary flakes (N = 19, 20.65%). Some blocks of diverse raw materials, including limestone, sandstone, chert and quartz were used as tool blanks (N = 7, 7.61%) Very few blade and bladelets were found (N = 4, 4.35%) and as with other regional assemblages

| Recorded lithic artifacts | Batch collected and sieved artifacts (counted but not recorded lithic) |
|---------------------------|------------------------------------------------|------------------|
| Lithic industry coordinate in excavation | 43 | Splinters and flakes <20 mm | 303 |
| Lithic industry removed in batch by spit | 48 | Others | 87 |
| Total | 91 | Total | 390 |
6.3.2. The raw material in Liang Pemalawan

The raw material assemblage from the lithic production in Liang Pemalawan is diverse. It is composed mainly of igneous rocks, cherts, quartzite (Lesan river pebbles), local limestone (directly from the shelter or neighborhood) and other siliceous sedimentary rocks like flints, chalcedony, and more rarely quartz. At this western part of the karst, the river reaches the Mesozoic-Early Cenozoic sediments of the Muara Wahau region at the base of the Oligocene karstic massif on the northern margin of the Kutai basin (Moss 1998, 1999; Cloke et al., 1999, Wilson and Moss, 1999). The sedimentary Late Cretaceous – Paleocene conglomerate is a mixture of igneous rocks (basalts), cherts and other metamorphics (e.g., quartz, quartzite). The chert group dominates in the lithic assemblage (nearly 75%) of the raw materials (e.g., chert, igneous rocks, quartzites), but some others, including flint and silicoid rocks, probably have tertiary sedimentary origins in the Oligocene (or Eocene) outcrops (Figs. 32 and 33).

6.3.3. The flaking technique

The flaking technique used at Liang Pemalawan is essentially by freehand hammer stone percussion (95.6% of the lithic products), producing rather short and thick blanks. The butts are wide, the bulbs are well marked and the incipient cones often visible. Only two cores were identified; both used limestone blocks. Very used up in character, they show the removal of short flakes in an opportunistic debitage strategy. The remaining lithic artifacts are blank flakes from an undetermined production technique (2.2%) or tools on blank blocks (2.2%).

6.3.4. The butts

The butts are mainly natural (30.8%) or smooth (30.8%). Prepared butts only represent 5.5% of the total butts. The absence of butts on some blanks is common, with an observed frequency of 29.7%. This can be explained by the fragility of some of the raw materials linked to an expedient debitage, i.e., a very low technical investment (e.g., overhang preparation). A few butt were, however, prepared (5.5%); some are on a break (2.2%) or less commonly dihedral (11%).

6.3.5. The cortical blanks

Most of the artifacts (N = 72, 79.1%) show cortical remains and those with a pebble cortex alone accounted for 58.2% of the artifacts (N = 53). The artifacts showing natural surface remains, account for 20.9%, including limestone (N = 14, 15.4%), quartzite (N = 4, 4.4%) and flint (N = 2, 2.2%) (Table 12).

6.3.6. The debitage: flakes and blades

There are only four blade blanks including three blades and one bladelet (total blade products: N = 4). These products are rare and rather short, and can be considered anecdotal in the debitage, just as at Liang Jon and Liang Abu. There is no reduction sequence remains that suggest a regular blade production and, moreover, the blade lengths are similar to those of the cortical flakes.

Concerning the flake assemblage two categories of blanks can be distinguished. Firstly, pebble flakes assemble around 30 mm in length and 30 mm in width. They are relatively thick; on average 9 mm in thickness. Most of the shaped tools (N = 8) from Liang Pemalawan are made on cortical flakes (from pebbles). Secondly, the non-cortical flakes are a little smaller, on average around 24 mm in length, 25 mm in width and 8 mm in thickness. Despite the expedient and opportunistic features of the debitage (in comparison with Liang Abu), the flake blank production at Liang Pemalawan can be stated to be differentiated. This is probably linked to a quasi-exclusive debitage on pebble (even if modest-sized) yielding two categories of blanks: decortication flakes and full debitage flakes. These blank populations obviously do not have the same vocation in the tool kit (Fig. 34).

6.3.7. The tools

There are very few tools at Liang Abu, at least regarding those that can be identified with the naked eye. We cannot exclude the presence of URT tools, but this requires further binocular observations and micro-wear analyses (Fig. 35). In this context, a thin study of all the debitage blanks could yield some interesting results.
The Liang Pemalawan identified tool kit (N = 12) is distributed as follows:

- Nine notches (N = 9). Six of them were shaped on pebble cortical flakes (N = 6), one on a full deblitage flake (N = 1), one on a chunk (N = 1) and one on a block (N = 1).
- One denticulate on a big quartzite pebble cortical flake, fully ochre-tinted.
- One retouched pebble cortical flake (lateral and inverse use retouch).
- One flat pebble in fine grain quartzite and fully ochre-tinted.

6.3.8. Products with ochre traces

Moreover, four artifacts are ochre tinted. Two of them are tools. One is a fully ochred denticulate shaped on a big first flake from a quartzite pebble (see Fig. Nr. 37). The second tool is a raw fine-grained quartzite pebble, widely tinted. Two others are raw pebble flakes (fine grained quartzite and igneous rock) showing some ochre traces. The purpose of ochre tints and the function of these artifacts are currently unknown; further studies are required including micro-wear analysis (Fig. 36).

6.3.9. The lithic of Liang Pemalawan: synthesis and conclusion

Despite the small size of the lithic sample from Liang Pemalawan, it gives a lot of information on the technological behavior and raw material procurement strategies of the upper Lesan people in recent prehistory. It complements the results obtained in Liang Abu by determining the precise geological origin of some raw materials (i.e., those found in Liang Abu) and some pebble flaking procedures. Even if there is only one reworked archaeological level (SU1), without taking into account the current-day Lebbo/Dayak level, the homogeneity of the lithic assemblage can be argued since the associated earthenware remains, even if in disorder, correspond to each other throughout SU1 (Plutniak et al., 2014). It still emphasizes the uniformity of the regional debitage and its continuity through time. The average size of the flakes is around 30 × 30 mm, and the deblitage method and flaking techniques are the same as those of Liang Abu. The raw materials found at Liang Pemalawan are also similar to those at Liang Abu.

One date was obtained for Liang Pemalawan from a charcoal sample removed in TP2 at the base of a small fire structure in contact with SU3. The date obtained is 720 BP (BETA 353017, 14C AMS — charcoal). This date seems very recent compared with the similar earthenware sample of Liang Abu and with the dates obtained for SU2 in Liang Abu (UBA-20839: 1672 ± 21 BP and UBA-20840: 1524 ± 22 BP).

7. Conclusion and discussion

More broadly, this lithic production type might be associated with other regional examples, including the Upper Birang site assemblages (Ariffin, 2004, 2006) or perhaps Gua Babi in the Meratus mountains (Widianto, 1997), but there is a lack of data for this site, only few illustrations. The study of the site of Kimanis site lithic assemblage shows few analogies with those of Liang Abu and Liang Pemalawan (raw material, size and techno-typology of the artifacts). The described assemblages come from a test-pit and from level C4 (KMS/TP and KMS/C4).

First observations suggest that the lithic assemblages collected in the three excavation sites look very similar. Regardless of the site or chrono-stratigraphic unit taken into consideration, the deblitage is essentially made up of flakes, and reflects an expedient stone flaking technology (Parry and Kelly, 1987; McAnany, 1988; Shott, 1989; Inizan et al., 1999; Bailly, 2002a, 2006; Astruc, 2005) of freehand hammer-stone percussion on small blocks, pebbles, little
flint nodules, big flakes (cf. about Kombewa flakes infra) and fragments. In each site, the majority of the blank flakes produced do not exceed 30 mm length and 30 mm in width.

There is extremely low frequency of blades. This typo-technological trait is considered as anecdotal, as there was no evidence of any deliberate blade production after studying the reduction sequences remains. The set of tools is mainly restricted to a few classes, such as used raw flakes (URT tools), notches, denticulates, splintered pieces, side scrapers, shaped on blocks, flakes and various fragments. There are no arrowheads or bifacial pieces.

The frequency of kombewa blanks is noteworthy, mainly at Liang Jon and Liang Abu; this reveals a recurrent debitage on flake blank cores (Owen, 1938; Daupois, 1981; Inizan et al., 1995; Tixier and Turq, 1999). Regarding the high rate of these blanks (reaching 25%) in some layers of Gua Tebok and Liang Jon. This flaking mode is not a priori exceptional in a techno-cultural sense, but it is intrinsically related to the local supply of raw material (implying a primary off-site reduction sequence) brought back to the sites in the form of big flakes that have been used as core. This behavior may express a deliberate technical choice with a view of saving a raw material which was difficult to source, or had limited or no availability in the neighborhood (Bernard-Guelle and Porraz, 2001). This practice is not necessarily opportunist and has been integrated into a general framework of debitage economy (Geneste et al., 1997, Tixier and Turq, 1999). Furthermore, other references of this type of blank in other parts of ISEA, including Liang Bua (Flores) where the Holocene unit 9a (dated 11 to 3000 BP, Roberts et al., 2009, Westaway et al., 2009) shows among other related products some Kombewa flakes considered as “Contact Removal Flakes” by the authors as they are integrated in a particular reduction sequence using flake blank cores (Moore et al., 2009) that also exists in the Upper Pleistocene units 2, 3 and 4.

During the 2007 excavation, particular flakes were remarked into the collected lithic assemblage. These flakes show systematically some marked scars on the dihedron butt/upper face (caster angle). If in certain cases these scars may be interpreted as technical preparations due to their ambiguous character (overhang platform abrasion), in some other cases it is clearly intentional retouch or use retouch (e.g., splintered edge, blunted edge) that may sometimes affect the butt. On one hand, intentional retouch can be linked to a reshaping or an adjustment of the dihedral active part (towards a linear dihedron), and on the other hand it may consist in a shaping by regular denticulation or notch removal. Some of these pieces show ochre traces (cf. e.g., Liang Abu below). Even if the possibility of press fit traces cannot be excluded (Beyries, 1987; Rots, 2011), the character of some scars clearly indicates the use of the upper face proximal dihedron. In this case it may be considered as a transformative or prehensive "techno-functional unit" (or TFU, Boëda, 1997, 2001; Forestier in Zeitoun et al., 2008). At this stage of the study it is still difficult to sort precisely these artifacts without a further micro-wear analysis and we shall confine ourselves here to classify these pieces as RCA tools (see above Liang Abu and Liang Jon lithic analyses).
For the two sites, Liang Abu and Liang Jon, where a stratigraphy was determined, the typo-technological invariance of the debitage is significant. In Liang Abu, a real continuity of the debitage was observed throughout all the sequence, which is to say from the Late Pleistocene (i.e. LGM) to the historical era, namely from 19,761 ± 87 BP (AMS 14C for charcoal, unpublished) to 1524 ± 22 BP (AMS 14C for charcoal, Ricaut et al., 2012). This “monotony” was also found in Liang Jon but it covered a shorter period, i.e., at least from 10,260 ± 60 BP to 995 ± 30 BP, (14C for charcoal Gay, 2010) as we could not get an exhaustive stratigraphy or a sufficient number of datations. These continuities in the lithic production systems over a long period were also found in the lithic assemblages of Upper Birang (e.g., in Kimanis, from 11,270 ± 220 BP to 1270 ± 240 BP, Arifin, 2006) and in other locations within ISEA (e.g., Liang Bua, Flores; Moore and Brumm, 2007; Moore et al., 2009) although this last case concern two successive human species (Homo floresiensis and H. sapiens).

A specific study of a lithic sample coming from Liang Abu showed clearly the existence of two classes of blanks with differentiated utilitarian vocation. This is also observed for the Liang Jon and Liang Pemalawan assemblages. Short and thick flakes (solid flake blanks) are shaped as notches, denticulates or used raw as splintered pieces or flake blanks (careened tools). This tool class is completed by a heavy tool set shaped on blocks, chunks or pebbles, from a morpho-technical point of view, in addition to the techno-functional units using the shaping removal negatives (notches, denticulates). Some lateral dihedrons created during the debitage of the thick flakes or by their intentional fracture were used as an active portion of the tool (raised edges, longitudinal or transversal breaks, dihedron upper face-but). These used dihedrons show a rather open angle between 70 and 90°. Kombowa blanks produced from flake blank cores, which were shaped or used raw as tools (URT tools, e.g., splintered pieces), can be included in the “solid” tool set due to their particularly robust edges associated to the biconvex sections.

The second class of tools (“lithosome” flake blanks) uses thin, light and small-sized blanks. The active portions are cutting edges, thin and fragile, used mainly raw or very lightly retouched.

The procurement of raw material was mainly carried out in the neighborhood of the sites, according to the geological availability of knappable material. Limestone may be considered a complementary material; its presence is ranked second (Liang Jon and Liang Pemalawan) or third (Liang Abu) after the local procurements, although its proportion in the assemblages is relatively high (Liang Jon, 20.1%; Liang Abu, 13.0%; Liang Pemalawan, 18.7%). Some other raw materials (e.g., silicified fossil wood, chaledony, jasper, quartz) complete the assemblages (local knappable rocks + limestone) of the sites; these materials are rare across all of the sites (Liang Jon, 2.6%, Liang Abu, 5.0% and Liang Pemalawan 6.6%). This may suggest the procurement of raw materials over long distances, but also the exploitation of rare materials due to the scarcity or inaccessibility of knappable raw material. The proximity of such material, however, does not necessarily change the characteristics of the debitage or tool production. It remains expedient and produces flake blanks for informal tools. It has been suggested that an expedient- or informal-tool technology marks the sedentary nature of a population, while a formalized tool technology would characterize a mobile population (Andrefsky, 1994, 1998).

Regarding form, these tools are mainly unstandardized or casual. These lithic productions are supposed to be made, used, and discarded within a relatively short time period. This type of tool may be considered as a gear corresponding to a present situation or used in response to real-time conditions, rather than for future events or situations (Binford, 1979). There is no “formal” tool typical of mobile populations (Goodyear, 1979; Andrefsky, 1994: 22), since this equipment can be rejuvenated and can be used during long distance travel away from raw material outcrops. In our studied cases there is no evidence of a portable tool set except some grinding or polishing tools on pebble. Meanwhile, the manufacture of formal or informal tools may be linked to the availability of the raw material (Andrefsky, 1994: 22). The expedient lithic production may also be related to an opportunistic use of local resources in the framework of an ancient technical mobility (“... une technologie ancienne...”, Martinez-Moreno et al., 2006). Moreover, the micro-wear analysis could enlighten our studies about some reasons of the techno-economic behavior of these populations (Philibert, 2002). This poses the question regarding the mobility of hunter-gatherers populations in East Kalimantan inland rainforest territories.

The continuity and uniformity of the lithic productions over a long time period (potentially several 10,000 years in Liang Abu) may be linked, at least partially, to the environmental context. It appears that contrary to the northern and western area of Borneo Island, the rainforest vegetal cover did not change at least over the last 40,000 years in the eastern equatorial part of the island, even during the last glacial maxima (Wurster et al., 2010). Consequently, there were no notably changes in food availability and other natural resources, and therefore, no changes in technological behavior. On the other hand, the technological simplicity of the lithic assemblages (e.g., the absence of lithic projectile points or blade debitage) may suggest a complementary vegetal technology, although some bone industry conforms to the lithics (e.g., in Liang Jon and Liang Abu). This vegetal economy has already been emphasized previously (Gourou, 1948; Van Heekeren, 1972; Testart, 1977; Forester and Patole-Edouomba, 2000; Forester et al., 2006a; Zeitoun et al., 2008; Forester, 2010).

Regarding the recent settlement phases of the sites and the arrival of earthenware artifacts, there is no visible change in the lithic technology as has been observed in Kimanis (Arifin, 2006: 155). There are no blade flaking products comparable with those found in other contemporary sites in the northern part of the island (e.g., Bukit Tengkorak, Bellwood and Koon, 1989). In addition, even if there are some tool fragments on pebbles showing polished areas, there is no evidence of tools such as adze or polished axes. Moreover, there are no domestic faunal remains (e.g., pigs) in the studied faunal assemblages and no evidence of rice despite water sieving tests in Liang Abu and Liang Pemalawan.

In conclusion, despite the presence of earthenware in the upper levels at Liang Jon and Liang Abu and in the archaeological level at Liang Pemalawan, there is currently no evidence to evoke a “neo-lithization” (comparable to this of Niah Caves, Barker, 2005; Barker and Richards, 2012 or Gua Sireh, Bellwood et al., 1992) of human groups that frequented the sites of Lesan and Jelai from the Late Pleistocene until the historic period. There is evidence, however, of contact between these hunter-gatherer populations and farmer groups (Arifin, 2006), which frequented perhaps the coastal lowlands, from at least 2685 ± 35 BP in Liang Jon and 1672 ± 21 BP/ 1524 ± 22 BP in Liang Abu. These dates correspond to the third phase of pottery diffusion in SEA, as suggested by some authors (Wibisono, 2006). Nevertheless, for the case of the red-slipped ceramic discovered at Liang Jon (Plutniak et al., 2014), this ceramic type was already broadly diffused in SEA and the Cagayan Valley of northern Luzon in the Philippines islands around 2000–1800 BC (Bellwood et al., 2011) and in the Marianas islands in 1500 BC (Carson et al., 2013). On the other hand, the persistence of dense rainforest in East Borneo over a long time period (even throughout the LGM) could have slowed down human dispersal in this area. This is in contrast to the northern and eastern areas that had common open woodlands and savanna habitats until the
beginning of the Holocene. As suggested by Wurster (2010), this fact “provides an alternate scenario for human migration into Sundaland that does not require penetration of large areas of dense tropical rainforest” and could explain, at least in part, a certain techno-cultural endemism of the prehistoric populations in the inland rainforest areas of Eastern Borneo.

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