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Usewear and residue analysis: contribution to the study of the lithic industry from Tabon Cave, Palawan, Philippines

*Hermine XHAUFLAIR * & Alfred PAWLIK***

* Département de Préhistoire du Muséum national d'Histoire naturelle, Institut de Paléontologie Humaine, 1, Rue René Panhard, 75013 Paris, France.
hermine_xhauflair@hotmail.com

**Archaeological Studies Program, University of the Philippines, Diliman Campus, Quezon City, Manila, The Philippines.

SUPERVISORS : Claire Gaillard, Alfred Pawlik

Abstract

Tabon Cave yielded occupation layers spanning from the Upper Palaeolithic to the Neolithic. Our interest focused on the stone artefacts: What can they tell us about the activities that took place in the cave many thousands of years ago?
To identify and understand the use damages on archaeological pieces, a series of experiments was conducted, adapted to the tropical environment and to the raw material of many of the artefacts from Tabon.
The archaeological material analysis emphasizes the vegetal resources exploitation by prehistoric groups who stayed at Tabon Cave and a short-term use of the tools.

Résumé

La grotte de Tabon a livré des traces d'occupation s'étalant de la fin du Paléolithique au Néolithique. Notre intérêt s'est porté sur les outils lithiques : Que peuvent-ils nous révéler sur les activités qui ont eu lieu au sein de la grotte il y a des milliers d'années ? Afin d'identifier les traces d'utilisation sur les pièces archéologiques, une série d'expérimentations ont été réalisées, adaptées à l'environnement tropical et à la matière première des artéfacts. L'analyse du matériel archéologique met l'accent sur une exploitation des ressources végétales par les groupes préhistoriques qui ont occupé la grotte et une utilisation de courte durée des artéfacts.

Keywords: functional analysis, lithic industry, Southeast Asia, experimentations.

Introduction

This paper presents the functional analysis of lithic artefacts recovered at Tabon Cave, Palawan, Philippines. The work is twofold:

The first and experimental part tries to determine what are the damages, traces or residues resulting from the use of stone tools to work natural materials specific for Southeast Asia. Additionally, a sequential experimentation has been conducted to test how the lithic raw materials from Tabon are reacting to use.

The second part of the study is the analysis of the archaeological material. It aims to answer the following questions: What was the function of the lithic artefacts discovered at Tabon Cave? Can we reconstruct the activities that took place in the cave thousands of years ago? Do we observe choices to use specific tools in particular? How long time have they been used? And finally, what information can be retrieved about the use and exploitation of the local resources and the environment of the people who stayed at Tabon Cave?

Regional setting and method

Tabon Cave was discovered in 1962 by a team of the National Museum of the Philippines headed by Robert Fox. It yielded several prehistoric occupation layers ranging from the Upper Pleistocene to the mid Holocene (Fox, 1970). They delivered for the first time evidence for the presence of hominids in the Philippine archipelago. The human fossil bones of the so-called "Tabon Man", actually the remains of several individuals, have been identified as *Homo sapiens* and are among the oldest fossils of this species unearthed in Southeast Asia. Recent U-series measurements have delivered dates as early as app. 47ky (Détroit *et al.,* 2004). Only few faunal remains are present in the archaeological record. Soil micromorphology studies have shown a scarcity of charcoal and an absence of trampling evidence. This led to the conclusion that the cave had been occupied during short stays (Lewis, 2007). Nevertheless, thousands of stone artefacts from Upper Palaeolithic to Neolithic layers were excavated (Fox, 1970; Corny, 2008).

The originality of the use-wear method is that it defines a tool, not as a retouched blank, but as any piece which has been used, in a mechanical meaning (Semenov, 1970; Vaughan, 1985; Pawlik, 2001, 2004). This approach is particularly interesting for the Southeast Asian industries that can be characterised, broadly speaking, as resulting from simple production techniques and by the lack of a clear typology due to the paucity of retouched tools (Hutterer, 1977; Reynolds, 1993). Use-wear is an actualistic method: to be able to identify the use traces on the archaeological material, a series of experimentations was realised.

Experimentations on Southeast Asian contact materials

At the Archaeological Studies Program University of the Philippines, the conducted experimental framework focused on Southeast Asian contact materials. Until now, only very few experimental references with relevance to this region are available (Mijares, 2002; Davenport, 2003; Teodosio, 2006; Borel, 2008, pers. com.).

Methodology

Flakes were produced by knapping from a nodule of high quality flint from Texas. They were described, measured and inspected with stereo- and reflective light microscopes before any utilisation in order to be able to distinguish between irregularities already present on the experimental tools and the surface modifications due to the use. They have immediately been packed in individual plastic bags to avoid any contact with another material.

The flakes were used to realise ten different activities related to the natural resources offered by the tropical environment of the Philippines, such as sawing bamboo, piercing shells, and descaling fish (Fig. 1). They have been precisely described, documented by pictures and timed. The contact materials as well as the process employed to work them correspond to archaeological or ethnological data.

Cutting squid *(Loligo vulgaris)*	40 min
Sawing bamboo *(Bambusa blumeana)*	50 min
Procurement and cutting of a banana leaf *(Musa sp.)*	20 min
Shell drilling *(Tridacna gigas)*	4 h
Shell engraving *(Tridacna gigas)*	15 min
Fish descaling *(Ellochelon vaigiensis and Coryphaena hippurus)*	20 min
Processing fish *(Ellochelon vaigiensis and Coryphaena hippurus)*	80 min
Cutting meat *(Sus scrofa domesticus)*	25 min
Processing pork leg *(Sus scrofa domesticus)*	70 min
Scrapping fat and meat on pork bone *(Sus scrofa domesticus)*	16 min

Fig.1. Experimentations on Southeast Asian contact materials**.**

After their utilisation, the experimental tools were cleaned with water and soap before the stereo microscope analysis (6,3x to 57x). For the reflective light microscope (100x, 200x and 500x), the procedure was more elaborate: to remove everything that could reflect the light like finger prints or fat, and therefore distort the analysis, the flakes were placed inside an ultrasonic tank in a bath of soapy water for 15 minutes and then rinsed in 70° alcohol. At this stage, the tools were always handled with latex gloves. All observations were verbally recorded on forms, microphotographs were taken and the locations of the traces were marked on photographic images of both faces of the experimental tools.

Results

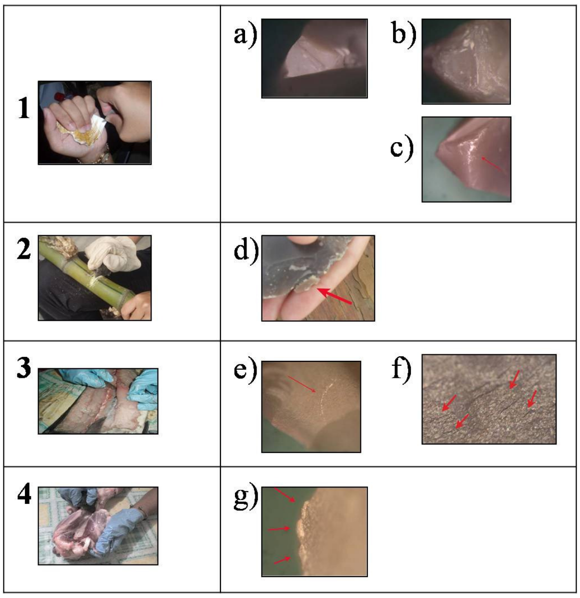

Fig.2. 1) Shell working. a) Drilling, before use. b) Drilling, after 15 min. of use: rounding localised all around the point. c) Engraving, after 15 min. of use: rounding localised at one angle of the appointed part. 2) Sawing bamboo. d) Macro-fragment breakage due to use. 3) Fish processing. e) Curved superficial striation indication the way of the motion, probably due to the contact with the bones. f) Deep striations on weak polish. 4) Pork processing. g) Bright well developed polish spots located on the edge.

The appearance of a pronounced rounding is particularly spectacular on tools used in the shell (hard mineral material) engraving and piercing experiments. Its localisation on the pointed ends of the flakes varied according to the motion: in the case of shell drilling, the rounding was located all around the pointed part. On the shell engraving case, the rounding appeared only at one « angle » of the appointed part (Figure 2). Various types of micro-scars have been identified. The most numerous appeared during the bamboo sawing experiment which also resulted in the breakage of a macro-fragment of flint. Different sorts of micro-polishes have been recognised, their intensity depending of the contact material and the duration of the use. Superficial and deep striations occurred on some of the tools and their relation with the gesture's way has been clearly demonstrated. The deep striations seem to be caused by the contact with hard and semi-hard materials, in the present situation with fish and pork bones. In one case, handling traces were recognized, materialised by a polished area and a rounding visible at microscopic scale. They were located on the butt of the flake, a part that hasn't been in contact with the worked material (fishes) but was hold in the hand during the all time (Fig. 2).

Sequential experimentation with radiolarian jasper

This part of the work has been realised at the Universitat Rovira i Virgili. The aim was to observe the effect of the utilisation on red radiolarian red jasper, raw material of many of the stone tools from Tabon (Schmidt, 2008). Thanks to the courtesy of P. Schmidt, we received a geological sample from the Malatgao River (located near the cave) having the same chemical elements and the same formation history than the raw material of the artefacts (Schmidt, 2008).

Methodology

An experimental flake has been produced by knapping. The block had many cracks which is common for jasper. This information turned out to be of particular interest for the understanding of the artefacts from Tabon cave. Nevertheless, the jasper blocks from the river banks close to the cave are suitable for knapping because they get strengthened by chalcedony crystallisation (Schmidt, 2008).

In order to remove eventual residual particles due to knapping the flake has been placed for 10 minutes, in an ultrasonic tank, inside an individual plastic bag containing detergent (Derquim LM 02 at 2%), immediately after its production. Then, a polyurethane cast has been made to record the exact state of the surface previous to any utilisation.

The experimental tool has been used to work wood, a contact material well know to create important wears. Two reference points have been observed and documented with SEM before utilisation (cast), after 15 and 30 minutes of utilisation.

In preparation to that, the flake was placed inside an individual plastic bag containing oxygenated water and put in an ultrasonic tank for10 minutes. After that, it was rinsed with water and placed again in the ultrasonic tank, this time in a 2% solution of Derquim LM 02. The last rinsing was done with pure acetone, then the specimen was dried under pulsed air. To make them conductive, the tool and the cast were fixed with glue on metal object mounts and sputtered with a thin golden layer. A silver line has been painted to link the pieces to the mounts. Finally, the flake and the cast were marked at the exactly same places with black marker pen.

After a first observation, the experimental tool has been washed with acetone to remove the silver line and soaked in a bath of HCL 75% and HNO_3 75% to remove the golden layer. It has been used for 15 minutes more to saw wood and then washed again and metallised following the procedure described above.

Around fifty micro-pictures of the reference points have been taken at several magnifications (50x, 100x, 250x, 500x, 1000x, 2000x) to compare the state of the surface at different use stages.

Results (Fig. 3)

The most obvious and rather striking development was a general abrasion of the part that has been in contact with the wood. The sharp edges became smooth, even at the scale of the crystals, producing a significant rounding. Also a loss of material was noted, sometimes in the form of micro-scars, and thus a decrease of the tool's size.

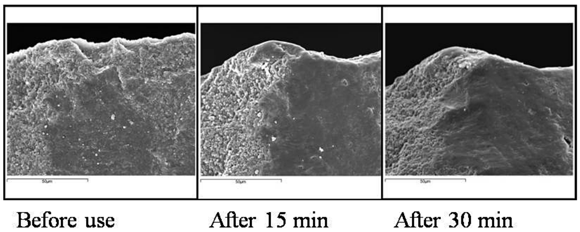

Fig.3. Sequential experimentation.

The development of micro-polish was also observed, mainly on protruded parts of the tool's working edge. Prolonged work did not always result in an increase of the polished surface. Some areas appeared to be polished after 15 minutes of wood working but the next round of use wore them out. After 30 minutes of use, they were partially rounded or micro-scars had removed part of their extent.

Therefore, it seems relatively impossible to determine exactly the duration of a tool's use solely based on the extent of micro-polishes.

Another interesting observation was that despite of the intensive cleaning, wooden residues were found on the flake. Their shape, as well as their chemical composition (mostly Mg and Ca) revealed by the Energy Dispersive Analysis of X-Rays analysis can be used as a reference for the residue analysis of archaeological material.

Analysis of the archaeological material

The artefacts analysis was carried out in the Lithic Studies Laboratory of the Archaeological Studies Program, University of the Philippines.

Corpus

Our initial sampling strategy was to select artefacts from the Assemblage III since it was probably undisturbed and well dated as spatially close to the charcoals used to make the ^{14}C dating published by Fox (Fox, 1970; Corny, 2008). At the time of this study (2009), only a small part of the Fox collection was available at the National Museum of Manila. The rest of the material was still stored at Baguio at the University of the Philippines. Due to this reason, as only the available artefacts could be selected for analysis, the sampling strategy had to be modified. The criteria for the selection were the presence of a potentially active part (cutting edge or point), a fresh and not much weathered or patinated surface and, as far as possible, a clear stratigraphical context, excluding the pieces coming from shallow depths.

Twelve stone tools come from Fox's (1970) Assemblage III and IV, 100 to 130 cm below the datum point at the surface. They form a spatially and temporally consistent group dating of the end of the Late Pleistocene, more precisely around 20 000 B.P. Three pieces come from the same area but from a depth approximately 200 cm. Three artefacts, from around 55 cm below datum point, appear to be part of Fox's Assemblage II. Another is associated with pottery and can be attributed to a Neolithic deposit or to disturbed sediments and a last one is isolated (Fox, 1970; Corny, 2008, 2010 pers. comm.).

Methodology

Previous to the use-wear analysis, the twenty tools were shortly described technologically and measured. Photos of both faces were taken and attached to recording forms, in order to localise the microscopes observations. The mapping of the traces observed on the artefacts helped in many cases to find the active part, to give clues about the kinematic and to determine, from their position, if the surface damages were due to the use or to other factors, post-depositional for instance.

All tools were examined first with a stereo-microscope, allowing 6,3x to 57x magnification (Low Power Analysis), and then with a reflective light microscope, capable of 100x, 200x and 500x magnification (High Power Analysis).

The significant elements were documented by micro-photographs: a digital camera was directly attached to the microscopes. To indicate the pictures size, small scales were photographed at all the possible magnifications and digitally added to the images using Photoshop.

The low power analysis under the stereo-microscope didn't require any particular preparation. Before the reflective light microscope analysis, the artefacts were placed 15 minutes in an ultrasonic tank in a bath of soapy water and 15 minutes more in 70% alcohol in individual plastic bags. If necessary, they were soaked in acetone before they were finally rinsed in 70% alcohol.

For recording and data management, an attribute system was created as MS-Access database with three data entry forms. They correspond to three analysis levels. The first one is resuming the naked eyes observations and the technological characteristics. The second and the third ones are for the stereo- and the reflective light microscopes analyses. They are largely based on the attribute system and recording forms created by A. Pawlik (1995) for his own research. The interpretation of the use traces was based on our personal experimentations and the following published referential records: Tringham *et al.* (1974), Keeley (1980), Odell & Odell-Vereecken (1980), Vaughan (1985), Levi-Sala (1986 and 1996), Shea & Klenk (1993), Pawlik (1995), Mijares (2002), Davenport (2003).

Attention was paid, at every level, to the post depositional surface modification (Levi-Sala, 1986, 1996; Shea & Klenk, 1993).

Results

Among the twenty artefacts studied, fifteen delivered sure utilisation traces. In average, they are not extremely developed.

One of the most remarkable elements highlighted by the analysis is that the large majority of the stone tools (13) showed traces of middle-hard to hard organic contact materials. This was revealed by frequent appearance of so-called smooth-pitted polish (bright and smooth spots located on the high parts of the micro-relief, more or less well linked), polished bevels, numerous deep striations on the surface and hinge, step and crescent break micro-scars along the edges (according to Vaughan's classification (1985)) (Figure 7). Two pieces present a polish produced by soft and tenacious materials, like skin or soft plants with low silica contents (Fig. 4).

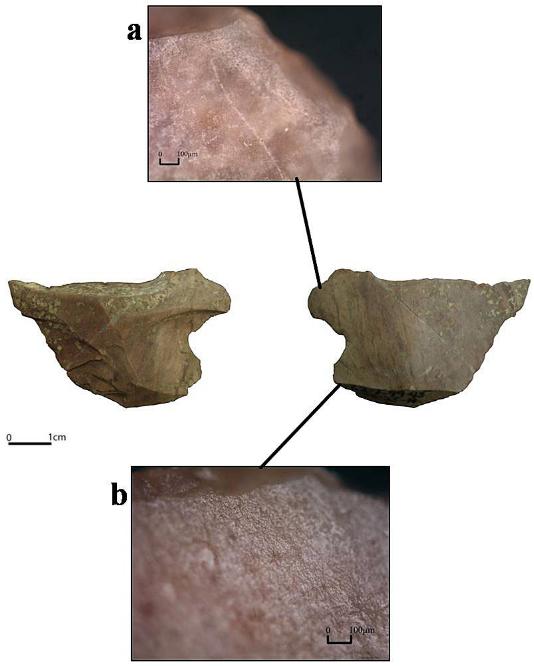

Fig.4. Artefact 62-T-10008. Used to work a) hard organic material (bone/antler/wood) b) soft contact material (skin/soft plants with low silica content).

The preferred face to be in contact with the worked material was the ventral one, except when the dorsal face was flat. This choice can probably be explained by a practical reason: a smooth surface doesn't obstruct the motion of the tool against the worked material. The tools were used almost equally for transversal (6) and longitudinal (5) motions. At least 3 showed complex kinematics (involving distinct motions), in two cases on different contact materials (Fig. 4).

Cores, flakes and shatters of the selected sample appeared to have been equally used. None of the pointed parts of the pieces (3) were used as indicated by the non-rounded sharp ridges of their extremity. No projectile damage was identified. Likewise, none of the small size artefact showed utilisation traces.

On one artefact, micro-rounding of polished zones located on three areas were interpreted as a result of prehension. On another artefact a bright spot was found, indicating a rubbing contact against stone or other stone tool(s), suggesting the storage or transport of the tools, e.g. in a pouch.

Numerous peculiar striations were observed, of types infrequent in literature. Some of them were positioned in a "brush stroke pattern", corresponding to a series of deep and superficial striations, alternating and parallel between them (Pawlik, 1995, 2009, pers. comm.). In some cases, they were curved, which is unusual but seen during our experimentations and resulting from a supple motion to cut fish. Another kind of striation pattern encountered can be described as curved superficial striations of a certain extent from the edge, seen on both faces of some of the artefacts. They suggest a stringy contact material. Davenport (2003) mentions similar observations about experimental tools used by Kamminga to work rattan (*Calamus sp.)*. (Fig. 5)

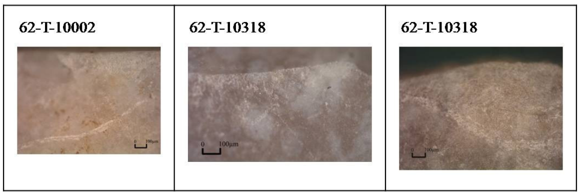

Fig.5. Peculiar striations. Due to rattan working?

Several residues were noticed, as black, brown and red amorphous spots on the tools surface. One remarkable discovery was a black residue, which preserved its structure and form, and clearly appeared to be vegetal (Fig. 6)
Some pieces had their surface totally covered by brown spots, which evidently indicated that they were post-depositional. Other post-burying alterations were observed, such as concretions on many artefacts, superficial striations in all directions and recent micro-scars.

Discussion

The high percentage of positive results (75% of 20 artefacts) can be explained by the bias induced by sampling. Indeed, some of the selection criteria aimed at choosing the most susceptibly used artefacts. This number is by no means representative of the entire lithic material discovered at Tabon.

A significant number of analysed tools were used to work middle-hard to hard organic materials. The panel of such materials is rather limited: bone, antler and wood. The fact that only a few animal bones have been recovered in the cave and the total absence of implement made of bone or antler incline towards the hypothesis of hard or semi-hard wood or bamboo working. Other elements support this hypothesis: firstly, the characteristics of the polishes, limited to the immediate edge, and adapting to the micro-relief of the rock without flattening it (except in one case). According to Vaughan (1985) such traces are typical of wood working. Secondly, the vegetal residue has been tentatively identified as a wood fragment. These results are similar to those obtained by Mijares (2004) who studied recently excavated flakes from Tabon.

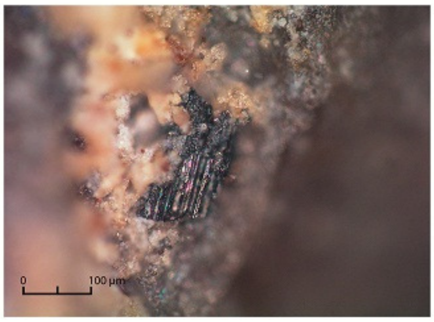

Fig.6. Vegetal residue, probably wooden fragment.

Some scholars (Pope, 1989; Forestier, 2003) explain the simple technology of the stone tools in Southeast Asia by the hypothesis that they were actually maintenance implements to make other ones in wood or bamboo. It is not possible to determine what are the exact activities made with the Tabon artefacts or if bamboo implements were manufactured. Nevertheless, although one has to keep in mind that only a small number of pieces was analysed here, and that therefore the information it can deliver is limited, this investigation showed that the subsistence economy of the human groups who stayed at Tabon Cave largely relied (if the sample is representative of the activities conducted in the cave) on the work and treatment of semi-hard and hard organic materials, probably of vegetal origin.

The fact that the majority of the pieces bear use traces that are not very intensive or developed, implies a short time use rather than a long caretaking of the tools and their transport from site to site. Besides, technological studies showed that the *chaîne opératoire* was complete (Fox, 1970; Patole-Edoumba, 2002; Arzarello, 2009, pers. com.), suggesting that most of the produced flakes were used for activities that took place inside or close to the cave and then abandoned on the spot.

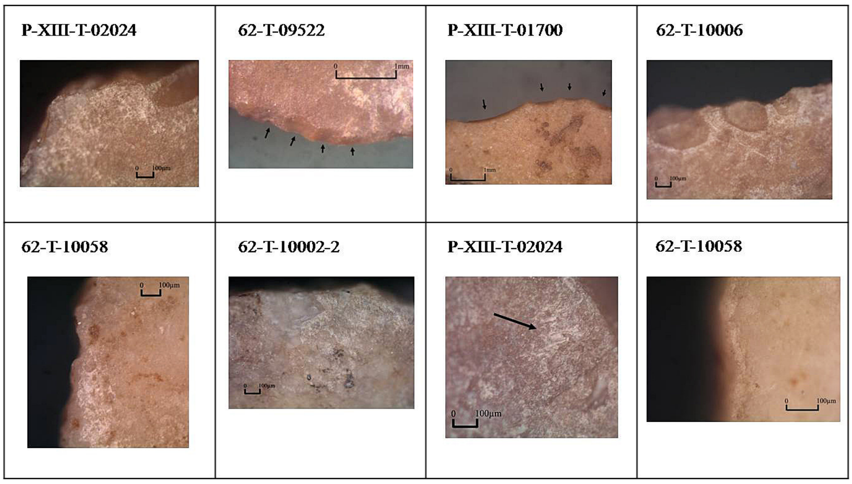

Fig.7. Use traces on hard and semi-hard organic materials. Above, from left to right: P-XIII-02024: Smooth pitted polish, 62-T-09522: Micro-scars row, P-XIII-T-01700: Micro-scars of crescent break type, 62-T-10006: Smooth pitted polish around micro-scars. Below, from left to right: 62-T-10058: and 62-T-10002-2: Smooth pitted polish, P-XIII-T-02024: Deep striations, 62-T-10058: Polish bevel (According to Vaughan's (1985) terminology).

Conclusion

The experimentations allow us to understand the formation and nature of surface damages of lithic tools due to utilisation as dynamic phenomena, and to have an insight of their variability. This step, necessary for any use-wear study, helps in building up a referential record of microwear and residues, especially for the Southeast Asian lithic assemblages, and allows a first decoding of the function of the artefacts discovered in Tabon Cave by Robert Fox.

This use-wear analysis suggests an exploitation of available vegetal resources by the prehistoric occupants of the cave. Cores, flakes and shatters were used indiscriminately, apparently for a relatively short time, inside the cave.

The study raises some questions, such as the meaning of the striations observed on the surfaces of many tools or the nature of the different residues. A comprehensive experimental framework considering the particular environment of this region is still lacking, but absolutely necessary to find clues. The residues discovered should be analysed deeper, notably chemically with appropriate technical equipment, for instance X-ray microprobes (EDX).

Applied on a selection of artefacts from the entire Tabon assemblage and to the lithic material from other sites of the same period, this kind of analysis will enlighten the behaviour and subsistence strategies of hunters-gatherers in Southeast Asia at the end of the Pleistocene.

Acknowledgments

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