INLAND SHELL MIDDEN SITE-FORMATION: INVESTIGATION INTO A LATE PLEISTOCENE TO EARLY HOLOCENE MIDDEN FROM TRÀNG AN, NORTHERN VIETNAM

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ABSTRACT

Over the course of the past couple of decades there has been growing research interest in the site formation processes of shell middens. This stands along-side and is being used to inform cultural, dietary and palaeo-environmental reconstructions. Just as midden site formation processes have turned out to be many and varied, however, the kinds of shell-bearing sites that past human communities created are likely to have been no less diverse. Subsuming such sites under a single category – shell middens – normalises that variation and may lead to the misinterpretation of site function. The greater part of research in this field also continues to focus on coastal shell middens; comparatively little attention has been paid to middens containing freshwater and especially terrestrial molluscs from hinterland locations. As a result, much of our current understanding about shell midden sites carries a spatial as well as a functional bias. With this paper we hope to contribute towards discussion on both fronts. We present a detailed examination of the formation processes that went into the creation of a land snail-dominated late- to post-glacial midden from northern Vietnam, and consider the role that it may have played in the early settlement of this area. The data presented comes from ongoing archaeological excavations at Hang Boi, a cave located in the sub-coastal karstic uplands of Tràng An park, in the Vietnamese province of Ninh Bình.

Keywords: Shell middens, site formation, mobility, Hoabinhian

1. INTRODUCTION

1.1 *Shell midden research*

As early as the 1830s, scholars had proposed that many of the shell mounds that lay along the world's coastlines were the product of human action. Systematic investigation of these mounds began in 1848, when the Royal Danish Academy of Sciences instigated a study group to examine the oyster and cockle shell *køkkenmøddinger* ('kitchen middens') on the Jutland coast. The six volumes of reports that emerged from this work in the early 1850s confirmed their human origin, patterns of accumulation and the environmental setting under which they had formed (Trigger, 1989:82). A nascent recognition of stratigraphy and site formation soon emerged in early studies of North American shell middens (e.g. Wyman, 1875:15-43, figure 1) and, later, attempts were made to calculate midden volume and rates of accumulation as estimates of site age (e.g. Cook, 1946). Most investigations continued to excavate in arbitrary spits, however, and little attention was paid to the shells themselves except as units of measure until the 1960s, when dietary reconstruction became a more central focus of archaeology in general. The exploitation of molluscs and the accumulation of shell mounds were now portrayed as part of a wider shift by post-Pleistocene groups towards secondary resources: a response to growing population pressure and changing environmental conditions, which had diminished the availability of preferred foodstuffs (Binford, 1968). It was not until the late 1980s and into the 1990s that researchers started to pay much closer attention to the site formation processes affecting shell middens (Claassen, 1998), and from this arose a much greater appreciation of their complex depositional histories. For example, in his study of shell mounds along the north Australian coast, Stone (1995) demonstrated that criteria such as size selection, the dominance of a single species, an absence of water-worn shell and the presence of clear stratigraphy can all be readily achieved by natural processes alone. While not denying that human agency can be implicated in many shell midden deposits, Stone cautioned strongly against the reliability of those criteria used by archaeologists, which were ultimately based on the findings of the early Danish research. Stein (1992) was another to prioritise the study of depositional and post-depositional processes in her excavation of an island site; the British Camp shell midden, just off Vancouver Island, Canada. Specific efforts undertaken here included: the identification and stratigraphic demarcation of individual dumping events; assessment of the extent to which ground water saturation was responsible for a change in the colour and sedimentary character between the upper and lower portions of the midden's stratigraphy (with the corresponding impact on the preservation of organics); and determining the sources of shell entering the midden, not only in terms of identifying natural species habitats but also in terms of identifying the processes that had affected different shell components (facies) on the way to their final incorporation. The current study pays similarly close attention to sedimentary changes as a guide to understanding site formation.

1.2 *Terminology*

In pursuing the biography of shell middens there comes a point where continued use of the term itself becomes an impediment. Referring to human-accumulated shell-bearing deposits consistently and repeatedly as 'middens' pre-supposes that all belong to the same class of site, rather than considering that they may have held differing roles in settlement systems or that a single midden may represent a palimpsest of different activities. There is a growing need for us to extend to human agency the same level of deconstruction and detailed analysis that has been applied to complex site formation processes, including transformation (e.g. for lime extraction) long after a midden had been abandoned (Ceci, 1984). Despite recognition of the problem, a concerted effort towards addressing it has not yet emerged and literature on the subject remains scarce. One of the most frequently referenced attempts at an alternative classification scheme for midden sites was first presented twenty years ago (Widmer, 1989).

Widmer proposed a typology for shell-bearing sites based on records from Florida. His classification system attempted to incorporate site formation processes and function to provide a more satisfactory set of descriptions. The first class of sites he identified were *shell midden sites*. Such sites result from a singular function, consumption, and occur where the shell component is the secondary deposit resulting from this activity. Shell-midden sites are task-specific and deposits should be void of vertebrate fauna and hold minimal numbers of artefacts. The second class, the *shell midden*, describes a discrete on-site feature that meets all the same criteria as the first class, but forms only one localised component of a larger site. A *shell-bearing midden site*, Widmer's third class, is composed of secondary refuse, but includes shell debris discarded from a range of different activities (of which consumption is only one). Thus such sites would also contain shell debris from craft or manufacturing activities. Widmer's fourth class was the *shell-bearing midden*, which paralleled the above 'shell midden' in that it described discrete areas of secondary shell refuse, but now from a range of different activities rather than consumption alone. The final class was the *shell-bearing habitation site*. These sites are often much more complex in terms of site formation processes and may contain natural (i.e. primary) shell deposits as well as secondary ones from human activity; shell deposits may have been used as a structural component of habitation (e.g. as fill for floors or causeways). Widmer drew specific attention to the fact that a shift in deposit composition may signal a change in the agents of accumulation or site-use over time. From this he also advocated treating shells as both sediment and artefact: as a medium manipulated by a range of natural and/or anthropogenic forces both before and after discard, as well as the accumulative by-product of human consumption.

Widmer's classification scheme acknowledged that shell accumulations need not be interpreted solely as a result of secondary deposition and highlighted that they are not necessarily just a passive cumulative refuse product: shell middens can be an active resource. What we hope to achieve here is the application of these principles, but also to begin the process of situating the shell middening activities of our case-study into its particular cultural and economic context: that of the Hoabinhian of prehistoric Southeast Asia. We retain use of the term 'midden' through our analysis until the specifics of our study site become more apparent and then, from this, offer a contextual refinement of the term that is in line with Widmer's scheme.

1.3 *Inland shell middens*

Choosing a contextual focus brings us to the second of the two biases that have tended to exist in this field of analysis, namely the extensive amount of work that has been carried out on highly visible coastal shell middens compared to the minor interest generated by inland shell middens. This is a bias that can have significant consequences for our understanding of the economic and settlement activities of prehistoric groups. For example, the role of coastal resources and 'strand-loping' are currently a prominent feature in models of early human dispersal out of Africa (e.g. Mellars, 2006). This leaves us to wonder to what extent such interpretations have been influenced by the fact that so much less information is available about inland shell middens compared to those along the coast. Following on from this we are concerned with how such a bias impacts on our understanding of the economic relationship (if such existed) between hinterland and coastal sites at the end of the last glacial when environments in northern Vietnam, as else-where, were under-going major re-structuring.

The analysis of inland shell middens has received some archaeological attention, although most studies (including Wyman's original work in Florida in the late 1800s) have been directed towards deposits of freshwater molluscs, and the assessment of their place in palaeo-diet (e.g. Erlandson, 1988; Lindsay, 2003; Parmalee and Klippel, 1974). Indeed, such sites do appear to fit within non-deconstructed definitions of the term 'shell midden', where land snail middens do not. For example, Stein (1992:1) writes: "All shell middens have certain properties in common. Shell comes largely from the hard parts of aquatic fauna (freshwater or marine), and sites containing shell are usually located adjacent to aquatic environments". This leaves land snail middens in a somewhat isolated category. Terrestrial molluscs are well known to occur naturally on archaeological sites (e.g. Medway, 1960) and within the landscape, sometimes in considerable numbers (F.Naggs, *pers. comm.*). They are also commonly accorded the role of environmental indicator as many have particular and localised habitat preferences (Drewett, 1999). This propensity to natural accumulation may partly account for their apparent exclusion from mainstream shell midden analysis. On those occasions where human introduction *is* the apparent agent of accumulation, however, land snails can bring an important added dimension to midden analysis. We can anticipate that the formation of such middens will have involved differences in collection strategy. For example, land snails are likely to have been collected on a more piecemeal rather than intensive basis as, unlike marine molluscs, they do not occur *en-masse* in 'beds'. Land snail activity cycles are also tied to different ecological forces (notably rainfall). In addition, middens of this sort often occur away from riverine habitats in upland locations; and even when they do not, the inclusion of land snails as an edible resource can have far-reaching implications that challenge received wisdom on resource exploitation, as a study into Holocene subsistence strategies from seven sites on the Batanes Islands, between northern Luzon and Taiwan shows. In their analysis, Szabó et al. (2003) were able to demonstrate that despite maritime locations, terrestrial resources, including significant land snail consumption, were a strong feature of these economies.

Despite their neglected status, land snail middens are a comparatively widespread phenomenon. For example, Lubell and colleagues (e.g. Lubell, 2004a, 2004b, Lubell et al., 1976) refer to hundreds of land snail middens from late- to post-Pleistocene contexts in the circum-Mediterranean region. Their studies draw particularly on the open-air 'escargotières' of the Capsian cultural complex (*c.*10 to 7 uncal. ka bp) from the upland interior of eastern Algeria and Southern Tunisia. Although land snails form the most common faunal component at many Capsian sites in these countries, their contribution to forager diet is considered to have been secondary to large vertebrates, such as hartebeest (*Alcelaphus buselaphus*), zebra (*Equus mauritanicus*) and barbary sheep (*Ammotragus levia*) (Lubell et al., 1976). In-keeping with prevailing models, the appearance of lower-ranked resources, like land snails, is taken to be a response to limited access to these preferred foods. Lubell (2004a:8) notes that what limited nutritional work has been carried out tends to indicate that land snails have a comparatively low fat content making them a poor source of energy. They do contain all the essential amino and fatty acids required by humans, but in quantities so small that basing an entire economy on them would be an unlikely. Five land snail species dominate most Capsian escargotières (*Helix melanostoma*, *Helix aspersa*, *Leucochroa candissima*, *Helicella setifensis* and *Otala* sp.); all are still extant and occupy different habitats. Lubell et al. (1976:919) concluded that 'differential exploitation of these species appears to have been a function of the site location and local environmental conditions at any particular time'. In essence, the Capsian sites were probably seasonally occupied (Lubell, 2004b); a feature that other researchers have proposed with respect to both salt-tolerant and freshwater molluscs (e.g. Claassen, 1986; Erlandson, 1988).

The existing studies of land snail middens make valuable contributions to what is still a small corpus of research. At present, though, there are still few detailed reports assessing site formation processes, or interpretations that attempt to deconstruct middening activities in order to track site function through time.

1.4 *Shell middens in Southeast Asia*

Investigation of shell middens in Southeast Asia began in 1860 (Earl, 1863; Evans, 1929; van Stein Callenfels, 1936). Earl's original report is informative with respect to the process by which the 'kitchen-middens' along the north west coast of Peninsular Malaysia were excavated for burning in local lime kilns. Passing remarks are also made about their composition (made up entirely of cockles) and the structure of two mounds, together with discussion of human remains recovered from them, but few specific details are to be discerned. Van Stein Callenfels' (1936) analysis of three mounds at Gua Kepah, in the same vicinity, provided considerably more detail, including a geological assessment that located the sites on the shore of an ancient estuary, and some attention to how the middens may have been formed. His excavation proceeded in spits and concentrated on identifying cultural and faunal remains, which were accorded to a variant of the late- to post-Pleistocene Hoabinhian cultural complex, first identified in northern Vietnam (see e.g. Reynolds, 1990). Most – though thankfully not all (e.g. Leong, 1999) – coastal shell middens in Malaysia have now been lost to industrial processing, as have large shell middens along a *c.*130 km stretch of Sumatra's north east coast (McKinnon, 1991).

In Vietnam itself, systematic analysis of coastal shell middens began in 1926-27 when the French geologist Etienne Patte excavated the site of Da But, an open-air locale 40 km inland from the present coast in the northern province of Thanh Hoa (Bui Vinh, 1991), immediately to the south and west of Ninh Bình province. Occupation at Da But is known to have lasted from at least *c.*6.5 – 5.5 uncal. ka bp, but a high water table has so far prevented excavation of the basal deposits (Nguyen Viet, 2005), so greater antiquity is anticipated. This site is interpreted as forming part of a localised cultural complex (the 'Dabutian') that appeared at a number of similarly placed locations in this part of the country (including the sites of Lang Cong, Con Co Ngua and Go Trung). Based on the combined evidence from these sites, the molluscan fauna suggest that the Dabutian economy saw a shift from including quantities of *Corbicula* sp. (freshwater clams) in its earlier phases to a greater frequency of marine molluscs during the period of the mid-Holocene high-stand, before returning to the exploitation of freshwater resources as the sea level stabilised (Bui Vinh, 1991).

Also starting in 1927, geological expeditions being undertaken by Madeleine Colani and Henri Mansuy into the Hoa Binh Province, southwest of Hanoi, began uncovering what were identified as kitchen-middens at inland cave and rock shelter sites. Their work led to the formal recognition of the 'Hoabinhian' in 1932 (see, Shoocongdej, 1996). Many of these inland sites were found to contain a mixture of fresh- and terrestrial molluscs at varying levels of abundance, some with freshwater species – such as *Melanoides tuberculata* - predominating (e.g. Matthews, 1966; Yi et al., 2008); others with high frequencies of terrestrial molluscs – such as *Cyclophorus fulguratus*, *C. siamensis* and *C. speciosus* (Hoáng Xuân Chinh, 1991; Reynolds, 1990). The shell-bearing deposits at Hang Boi fall into this latter category.

2. EXCAVATION AT HANG BOI

2.1 *Site location*

Hang Boi ('Fortune Teller's Cave') is a recently rediscovered complex of caverns lying in the north eastern portion of an isolated massif of highly-dissected Triassic limestone, on the southern edge of the Song Hong deltaic lowlands (Nguyêň Văn Lữ and Nguyen Cao Tâń, 2002; figure 1). The site is located at Lat. 20° 15′ 32″N; Long. 105° 53′ 17″E, 35.6 km from the present-day coastline and at *c*.78 m asl. The cave mouth has a SSE aspect and overlooks a small cultivated doline (an area of ancient solution and collapse that is often created as a result of palaeo-cave collapse). Both the cave and surrounding landscape lie within the boundaries of the Tràng An Tourism Resort, a park development being created by the Xuan Truong Construction Corporation of Ninh Bình covering *c*.2,500 ha of this massif. Archaeological work here is being undertaken at the request of the corporation. The Upper Cave (the modern cave mouth) is 19.7 x 10 m in area and is the principal focus of excavation. A large interior chamber (the Lower Cave) lies *c*.18 m beneath this area (figure 2). Preliminary archaeological and geomorphological assessment of both the Upper and Lower Caves is presented in Rabett et al. (2009). In the current paper we concentrate exclusively on working being undertaken in the Upper Cave. Thus far, through the course of two seasons of excavation, the Tràng An Archaeological Project (TAAP) has opened a single trench (Trench 1) here covering a total area of 9 m^2. The 2008 excavation took place in a 4 m^2 portion of Trench 1(figure 2). During our initial (2007) season digging proceeded in 10 cm spits (represented by the 5000-series context numbers referred to herein). During the 2008 season we switched to single-context recording (the 5100-series numbers).

The modern floor of the Upper Cave is relatively flat and made up of midden deposits that have accumulated behind a boulder rampart at the front of the cave, itself the result of roof collapse. The midden almost certainly covers the entire floor area (*c*.197 m^2); however, as much as a third of it is obscured beneath a flowstone layer that also cements shells and other material to a depth of 10-20 cm. Accurate quantification of the midden's volume is hampered by this partial visibility and uncertainty about the Upper Cave's basal topography. In the area that has been excavated, midden depth exceeded 2.7 m below the modern ground surface by the end of the 2008 season, but it is not known if this is a representative depth without investigation in other areas of the site.

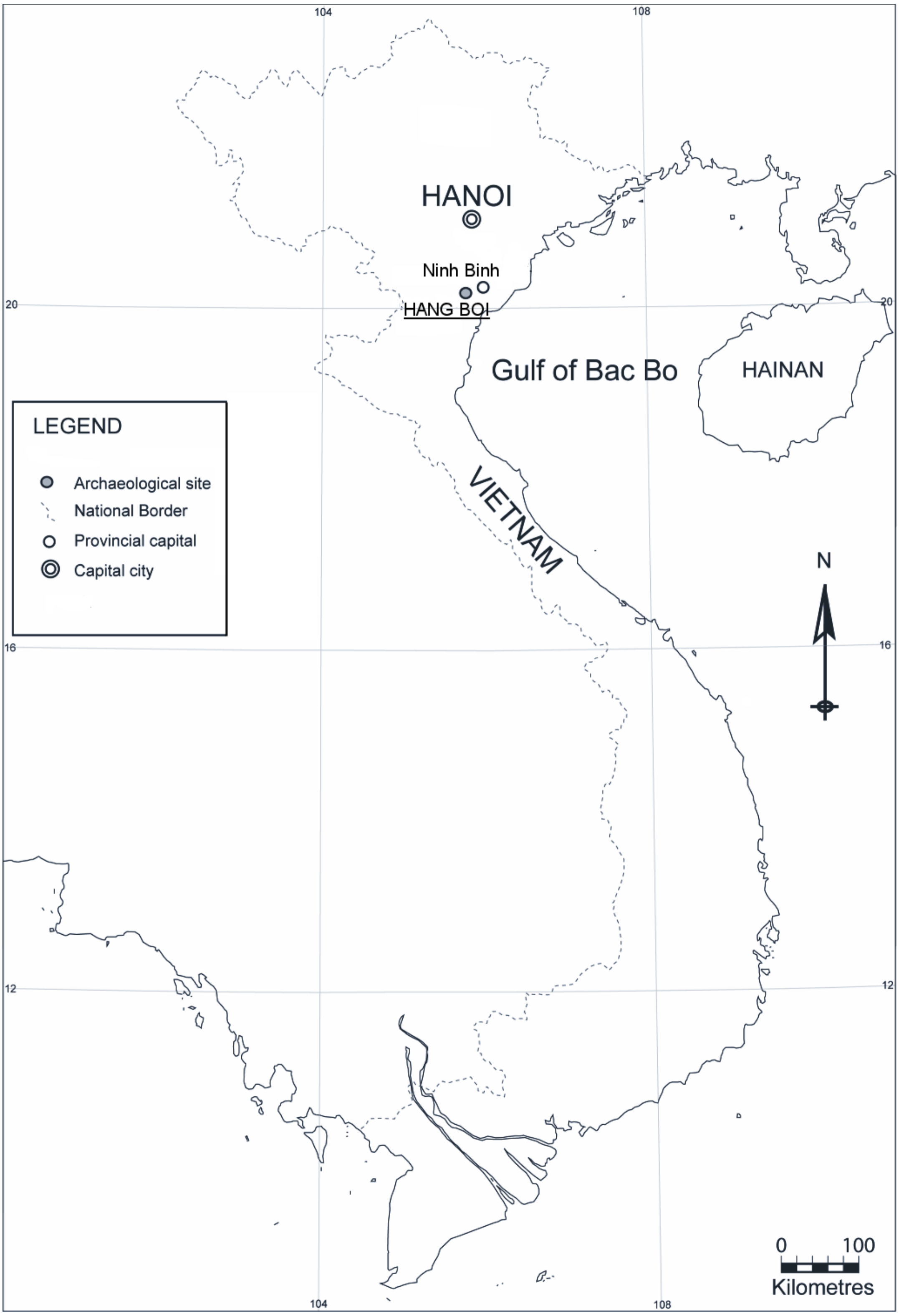

Figure 1, the geographic location of Hang Boi. A version of this map originally appeared in 'The Tràng An project: late- to post-Pleistocene settlement of the lower Song Hong valley, North Vietnam', adapted from a map that first appeared in the *Journal of the Royal Asiatic Society* 19(1) 2009. (Drawing by C.Stimpson.)

The Upper Cave also contains several relic crystalline flowstone deposits. Some of these are associated with cemented shell and bone remains, which we had previously taken to be the remnants of older midden deposits that are no longer present in the cave (Rabett et al., 2009:91-92). Here, we reconsider that interpretation on the basis of new evidence.

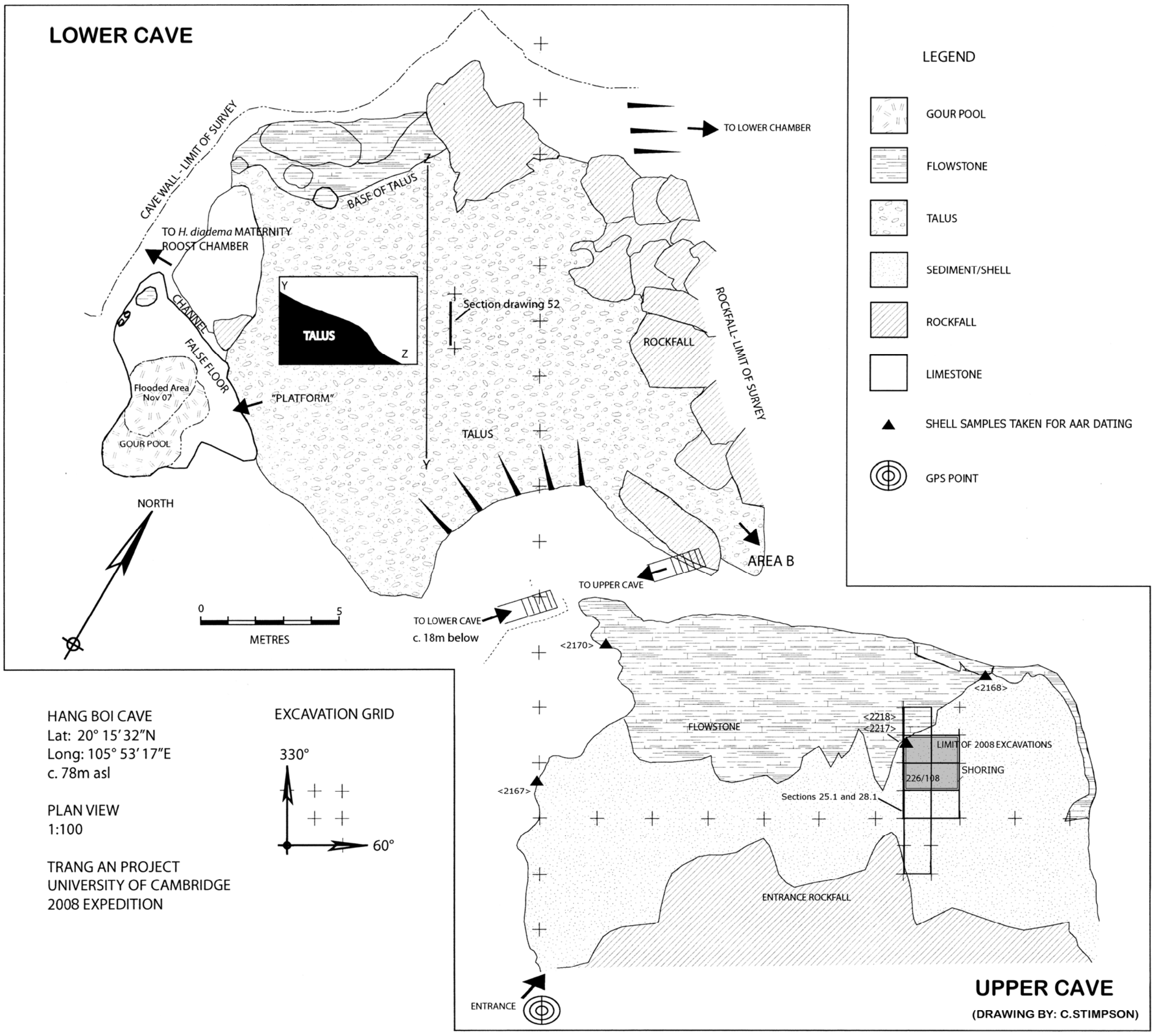

Figure 2, a plan of the Upper and Lower Cave at Hang Boi, showing the extent of excavations and cemented shell sample locations from the June-July 2008 field-season (shaded). Adapted from a plan that originally appeared in 'The Tràng An project: late- to post-Pleistocene settlement of the lower Song Hong valley, North Vietnam', which was published in the *Journal of the Royal Asiatic Society* 19(1) 2009. (Drawing by C.Stimpson.)

2.2 *On-site recovery strategies*

The 2008 on-site dry sieving strategy meant that every second (or in some instances every third) bucket was hand-sieved through 2 mm mesh. This procedure continued until we reached context (5125) in Trench 1 (figure 3). In the reduced excavation area afforded by site shoring measures, all excavated material from the lower contexts was sieved to maximise recovery. Bulk environmental samples for off-site wet sieving (through <1 mm woven fabric) were taken from all contexts in square 227/108 and supplemented where necessary by samples taken in the adjacent square (227/107). In addition, we collected a 20 x 10 cm sample column (figure 3) immediately adjacent to the 2007 column and extended this to context (5113). Sub-samples from the 2008 column have been studied for organic residues and lipids; palynological analysis of sediments from this sample column is pending. Finally, all fragments of charcoal ≥10 mm in size were given fully surveyed three-dimensional co-ordinates before they were removed. This proved to be a simple and effective way of accurately mapping the exact positions of 39 pieces that can form the basis of an archive of dateable material.

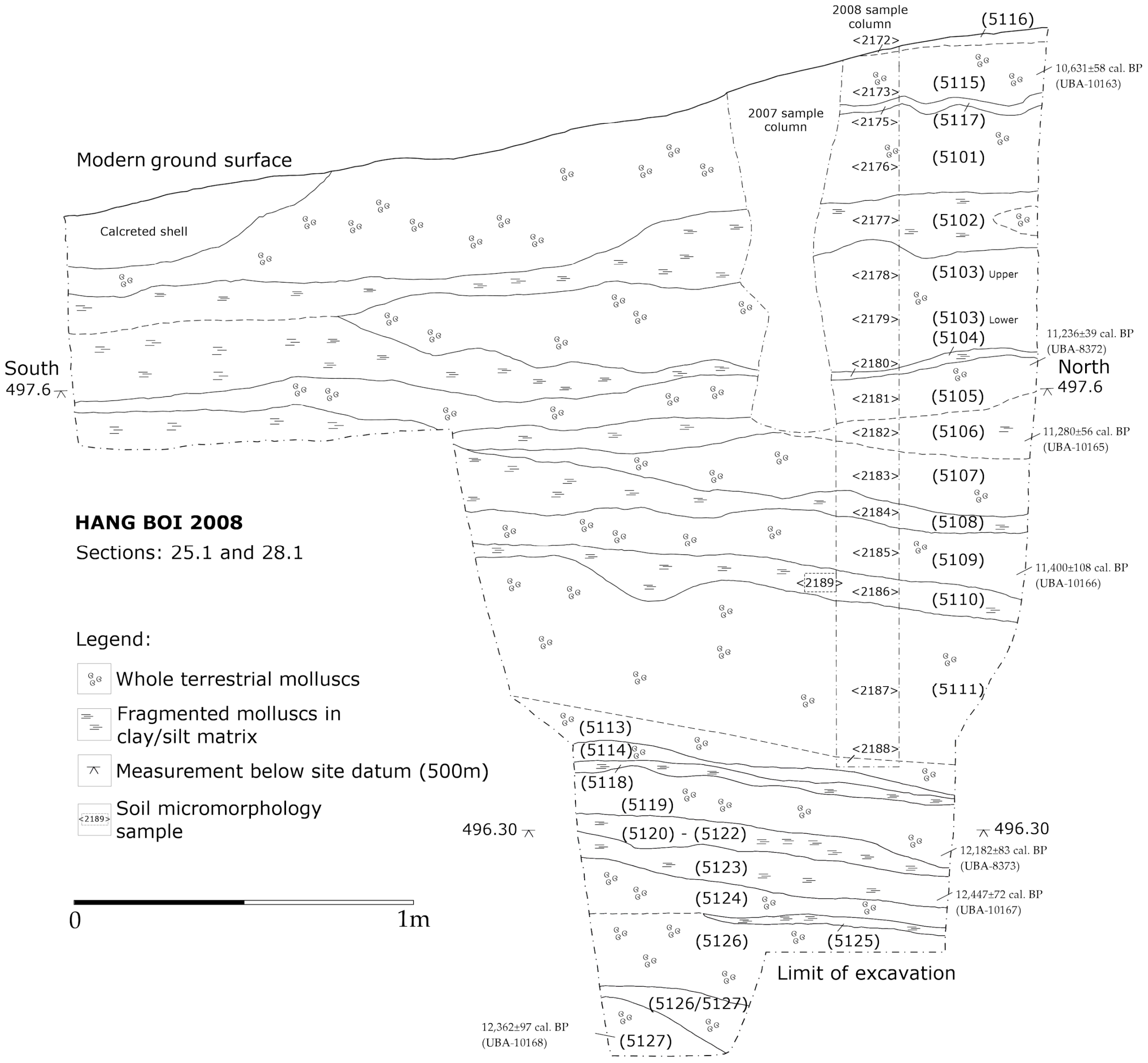

Figure 3, contexts and sample columns in the east-facing sections 25.1 and 28.1 (Trench 1), Upper Cave, Hang Boi. (Composite image by R.Rabett, based on field drawings by L.Farr, J.Appleby and Nguyêń Cao Tâń.)

3. CHRONOLOGY

A joint ^{14}C/AAR dating programme was instigated in 2007 to assess the absolute age of the shell-bearing deposits at Hang Boi.

3.1 *Radiocarbon dating*

The site currently has eight AMS ^{14}C dates distributed throughout the excavated sequence (figure 3, table 1). These provide ages for the top (immediately beneath the flowstone cap), middle and (current) basal deposits, as well as dates between immediately associated layers to examine depositional scheduling. All of the samples sent for AMS ^{14}C were fragments of charcoal; five of these have individually surveyed spot heights and spatial co-ordinates. All of the samples have been analysed by the ^{14}CHRONO Centre, Queen's University, Belfast and all calibrated dates have been obtained using the Fairbanks_0107 curve (Fairbanks et al., 2005). The results show very low error margins on mean calibrated estimates and demonstrate the potential for high resolution archaeological recovery at this site.

Grid Square	**Context/Spit**	**Max. depth (m)†**	**Material**	**Uncalibrated (years bp)**	**Calibrated (years BP)**	**Laboratory code**
226/109	5115	Sub-surface	Charcoal	9,406±44	10,631±58	UBA-10163
226/109W	5005D	497.90	Charcoal	9,397±49	10,620±64	UBA-08371
227/109E	5010=5105	497.60	Charcoal	9,863±59	11,236±39	UBA-08372
227/108	5106	497.26	Charcoal	9,900±50	11,280±56	UBA-10165
226/109	5109	497.06	Charcoal	9,981±45	11,400±108	UBA-10166
227/109E	5019	496.30	Charcoal	10,362±32	12,182±83	UBA-08373
DSW	5123	496.10	Charcoal	10,497±45	12,447±72	UBA-10167
DSW	5127	495.62	Charcoal	10,444±45	12,362±97	UBA-10168

Table 1, ^{14}C dates obtained from spit/contexts within the intact shell midden deposits, Hang Boi. † depth measurements are relative to an arbitrary 500 m TBM. 'DSW' = 'Deep Sounding, western half of trench'.

3.2 *Amino Acid Racemization dating*

Amino Acid Racemization (AAR) work has been undertaken at the NEaar laboratory, University of York. Preliminary proof-of-concept alpha-series assays were carried out on eight individual shells (cyclophorids) collected from four different locations around the Upper Cave in 2006 (Rabett et al., 2009: table 1 and figure 2). This pilot study established that it would be possible to produce viable intra-crystalline protein results for this genus of land snails (not previously used to obtain AAR dates).

Beta-series tests on new samples obtained in 2008 included modern comparatives identified to species, matched with five new archaeological samples of accurate provenance. These included two samples from ^{14}C-dated contexts in the main midden: contexts (5115) and (5123). The remaining three shell samples were taken from undated cemented shell-bearing deposits around the Upper Cave (see figure 2), including two fresh samples of cemented shell from deposits tested in the alpha-series. Our efforts to determine absolute ages on the intra-crystalline protein fraction of *Cyclophorus theodori* shells, though, did not meet with success. The decomposition patterns in *C. theodori* appear to be different to other molluscan taxa (there is greater racemization in the hydrolysed fraction for given free amino acid D/L values and high levels of free amino acids) and unusually variable – more so than has been observed in any other mollusc species analysed at the NEaar lab. It is hypothesised that the high level of variability within these shells may be due to calcium carbonate deposition from speleothem development in the cave. The shells did show evidence of speleothem deposits on their surface, and this may have introduced exogenous (but still preparatively intra-crystalline) amino acids into the shells. If the speleothem deposition is purely surficial, then potentially this could be avoided in the future by drilling the samples. However, if any speleothem has penetrated into the biomineral, this would be extremely difficult to remove. The variability may also be due to differential heating of the shells, either during processing for consumption, or due to deposition close to hearth deposits. The high variability in the dataset precluded calibration of the amino acid data using the samples of known age (i.e. samples of modern, *c*.10.6 cal. ka BP and *c*.12.5 cal. ka BP); however, certain preliminary and not insignificant conclusions did result from this analysis.

Sample	**NEaar number**	**Species**	**Quantity**	**Location**
2167	5781bF-5782bH	*Cyclophorus theodori*	2	Cemented shell deposit (Figure 1)
2168	5783bF-5784bH	*Cyclophorus theodori*	2	Cemented shell deposit (Figure 1)
2170	5785bF-5786bH	*Cyclophorus theodori*	2	Cemented shell deposit (Figure 1)
2218	5777bF-5778bH	*Cyclophorus theodori*	2	Dated context 10.6 ka (5115) (Table 1)
2217	5779bF-5780bH	*Cyclophorus theodori*	2	Dated context 12.4 ka (5123) (Table 1)
Modern	5787bF-5789bH	*Cyclophorus theodori*	2	On path to Hang Boi (15.05.2007)

Table 2, samples of *Cyclophorus theodori* obtained from Hang Boi and submitted for AAR dating.

Firstly, all of the tested amino acids were able to discriminate between modern and fossil material, and some (notably, serine [Ser] and alanine [Ala]) allowed discrimination between the radiocarbon-dated fossil samples, suggesting that these amino acids would probably be most useful in providing age resolution for samples of this general antiquity.

Secondly, the two ^{14}C dated samples <2217> and <2218> were demonstrably older than the undated (and modern) samples in the beta-series. Despite the observed variability in the results, the overall trend accords the samples relative positions in a sequence of increasing age with increasing depositional depth, with no anomalous reversals. This supports the results of our ^{14}C dating programme; however, it also introduces an unexpected conclusion: that the cemented shells of unknown age are *younger* than *c*.10.6 cal. ka BP (but probably not by many thousands of years) rather than older, as initially anticipated. Though we can treat this result as no more than tentative at present, due to the lack of detailed comparative data on this species, it has some potentially quite far-reaching implications for interpreting site history and use.

A Holocene occupation in the Upper Cave would also refute our previous thoughts about the timing of final site abandonment (Rabett et al., 2009). This would not only close the chronological 'gap' between the dated evidence from the upper cave and lower chamber (the latter in the form of recovered fragments of Da But pottery); it would also raise questions about the role of the site in local settlement of an increasingly maritime environment. The fact that only vestiges of a Holocene shell midden survive also indicates that one or more processes scoured the deposits from the Upper Cave during this period; we have yet to determine what these processes were and why they left the deeper midden intact. In the following section we set out the current state of our understanding about the site formation processes at Hang Boi.

4. MIDDEN ARCHITECTURE AND DEPOSITIONAL PROCESSES

Anthropogenic cave middens are likely to have complex depositional (and post-depositional) histories, with sediments becoming incorporated into the sequence from off-site (allogenic) and on-site (autogenic) sources via a number of pathways and processes (Woodward and Goldberg, 2001, table II). Allogenic sediments can be delivered to a site through colluvial (slope-wash and gravitational sediments), infiltration (water percolating through cracks and fissures in the host bedrock), aeolian (windblown material) and anthropogenic (deliberate or accidental addition to the midden) processes. Autogenic sediments, often coarser than the allogenic component, are commonly coarse angular sediments which are generated from the physical breakdown of the cave walls and roof; however, the insoluble fraction of the host limestone, comprising very small quantities (often < 2 %) of sand, silt and clay, may also contribute to the autogenic component, as do bird and bat excreta (guano), and other organic remains from flora and fauna inhabiting the site. Some of this material (notably guano, if in appreciable quantities) could have a very strong effect on other components of the midden, such as the shell carbonate. The inter-relationship between the depositional and post-depositional histories at Hang Boi is very apparent (figure 4), and future geoarchaeological work at the site will endeavour to quantify these processes.

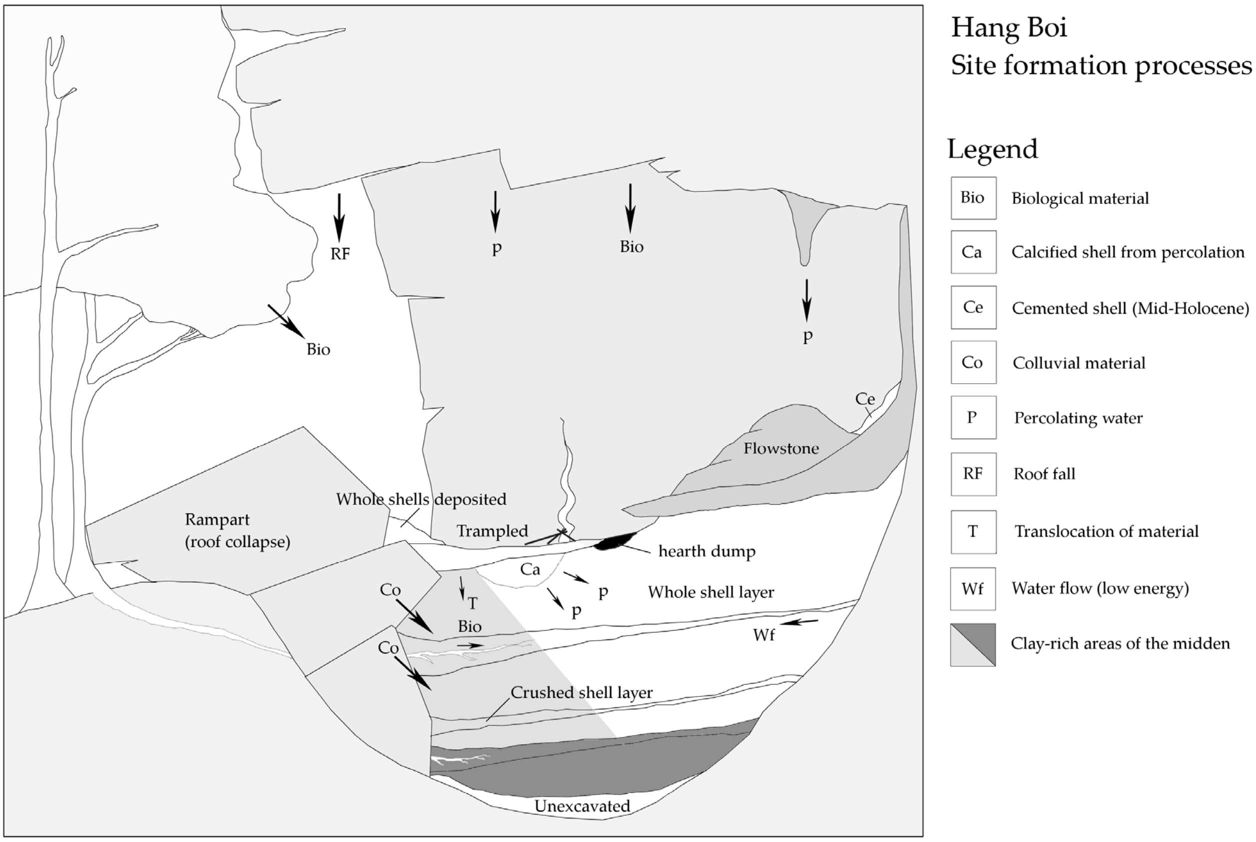

Figure 4, a schematic diagram of the Hang Boi midden showing the principal processes that likely contributed to its formation. (Drawing by R.Rabett.)

4.1 *Whole shell contexts*

The Upper Cave midden at Hang Boi is formed from frequently alternating layers of almost entirely whole shells with very small proportions of fine silt matrix sediment, and clay-silt/crushed shell layers (see figure 3). The whole shell layers are characterised by their extremely loose and friable consistency and their comparatively higher quantities of vertebrate faunal remains, charcoal fragments and other cultural material. There are also no obvious bedding structures within these layers. In the upper part of the sequence, the whole shell layers are of greater thickness towards the rear of the cave mouth, gradually thinning towards the entrance. This probably results from one or more of the following factors: a) the rear of the cave was the primary location where midden material was introduced, b) the cave floor/midden naturally formed gradual slopes dipping towards the rear of the cave which have been filled with midden material (e.g. see the relationship between 5104 and 5103 in figure 3), and c) there has been less disturbance to these friable shell layers towards the rear of the cave. All of the whole shell layers near the top of the sequence contain slightly more matrix sediment closer to the front of the cave. The upper part (*c*.5 cm) of individual whole shell units was frequently found to have proportionally more clay-silt matrix than the lower parts. This may indicate that there was some post-depositional translocation of fine sediment downwards through the profile, or that this was natural sedimentation between periods of site use. The whole shell layers appear to represent human occupation and food refuse. The rate of accumulation was probably quite rapid.

4.2 *Crushed shell contexts*

The clay-silt/crushed shell layers are of a variable light compaction. These layers were identified during excavation by a noticeable change in texture and consistency from the whole shell units. The clay-silt/crushed shell layers generally contain fewer cultural remains and where faunal remains were found to be present they were often heavily encrusted with calcite, which may suggest diagenesis (chemical changes) within the sediments. Some possible bedding laminations were visible in the exposed sections of the crushed shell layers, with the dip of the bedding structures varying from horizontal to a gently sloping gradient, S–N, towards the rear of the cave mouth.

The clay-silt/crushed shell layers were sometimes found to be thicker in depth towards the front of the cave. Towards the top of the sequence, crushed shell contexts (5102), (5104) and (5108) contained less clay-silt matrix towards the rear of the cave. These areas were characterised by thin layers composed of crushed shell with limited amounts of fine silt matrix. The depositional processes responsible for this are unclear at this stage, but one or more of the following are plausible: a) light foot traffic, b) the collapse or movement of whole shell midden layers at the rear of the cave onto a lightly trampled surface, c) a reduction in the amount of colluvial sediment reaching this far into the cave, d) thinning due to localised water-flow events transporting sediment in these layers from the back of the cave towards the mouth, e) localised diagenesis of deposits as a result of water percolation. The greater proportion of clay sediment in these layers towards the front of the cave is consistent with an increase in material entering the cave through colluvial and infiltration processes. Bedding laminations observed in some crushed shell contexts (e.g. 5104, 5108, 5120 – 5122), together with the gradual thinning of these layers towards the rear of the cave and flowstone curtain features on the rear wall, all accommodate a scenario of periodic low-energy water flow entering the midden. Percolating water continues to enter the Upper

Cave today after heavy rain and it is very evident that this has also caused water to seep through the midden in the past. Localised patches of dense calcite have formed on and within the midden in the proximity of the modern drip-line. The frequency of heavily encrusted bone fragments in many of the crushed shell layers is also consistent with this situation.

Towards the bottom of the excavated sequence, both the crushed shell and whole shell contexts (5120-5122 to 5127) have been found to be considerably more clay-rich than layers higher in the stratigraphy. This may signal post-depositional basal saturation, whereby ground water hydrated clay and organic compounds within the lower midden and leached out carbonates, ultimately disintegrating shells themselves. Alternatively, this change could signal a period of increased erosion/degradation outside the cave, possibly as a result of environmental change.

The first of these two scenarios represents a commonly reported feature of shell middens in other parts of the world (Stein, 1992). Usually a change in texture is accompanied by a pronounced change in colour between upper (lighter) and basal (darker) midden layers. As noted, percolating and dripping water is an active, if currently minor, agent in this cave system. Many features of Hang Boi, such as rock-fall deposits, fine-grained mud and flowstone curtains and floors characteristically develop under vadose conditions – mineral precipitation through water movement at or above the water table – and these might support the interpretation of post-depositional saturation. The young age of the midden deposits, however, means that they could not have formed when the cave was close to the regional water table. Additionally, there is no clear colour distinction between the upper and lower portions of the stratigraphy (using the Munsell system), which would be expected in this case, or between crushed and whole shell contexts. The change in sediment texture is significant, though, and bone fragments from the lowest contexts (5126 and 5127) exhibit a clear improvement in preservation, together with a markedly reduced incidence of calcification. Given that the age of the lower contexts is commensurate with the Younger Dryas stadial, it is feasible that these changes may be linked to wider differences in local climate regime, possibly to wetter conditions.

It appears that the clay-silt/crushed shell layers were formed by a mixture of anthropogenic and natural processes. The visual appearance of these contexts bears a close resemblance to the modern trampled ground surface of the cave (midden) floor, leading to the supposition that they may well have developed in a similar manner. The scarcity of archaeological and vertebrate fauna within these layers is harder to account for. It is possible that this is due, in part, to increased fragmentation, reducing ready-identification during excavation and increasing the likelihood of translocation of smaller fragments downwards into the spaces between whole shells in underlying deposits. Although some vertical movement of sediment is indicated, the fact that we have observed no significant variance in bone fragment length through the sequence, and that smaller elements, such as fish bones, are not confined to lower contexts, suggests that this would have been a relatively minor factor.

The second process in the creation of the clay-silt/crushed shell layers is indicated by the comparatively greater proportion of sediment found within them. We cannot yet control for the effects of changes in rainfall input on sediment accumulation rates; however, under constant conditions the time needed for higher proportions of colluvial matter to accumulate in these layers is likely to have been significantly longer than that necessary for the deposition of the anthropogenic whole shell layers. Thus, the two components of the midden probably accumulated at different rates.

A more protracted accumulation rate for the crushed shell layers finds support in the bat remains. The chiropteran fauna from the cave is still under analysis; however, initial identifications have revealed the presence of fruit bats (*Rousettus* sp.) in one of the crushed shell layers (context 5104). Predation of these bats by humans is not impossible, but it is more likely either that a small colony was living in the Upper Cave or that they were passing through the cave mouth to roosts deeper in the cave system. Fruit bats are known to be sensitive to human disturbance and their presence can be taken as a further possible indictor that there were sometimes extended periods of time when the cave was not being visited.

Not only does there appear to have been different rates of accumulation between the two principal midden components, but the processes of accumulation were also probably not uniform across the entire surface area of the Upper Cave. As a result, we might expect there to be some short-term jumps in chronology between apparently 'successive' layers because not all parts of the site were being used simultaneously. This, though, is unlikely to be recoverable by radiometric means as variance would probably fall within even tight error margins – as shown in figure 3 and table 1 for adjacent layers (5105=5010) and (5106). The different rates of accumulation do, though, also raise a third possibility for the creation of the basal clay-rich layers to the midden, namely: that they formed during extended hiatuses in shell deposition, and thus reflect a reduction in the intensity of site-use.

It is likely that the crushed shell layers have also played an important role in maintaining the midden's structural integrity. Horizontal root systems are found to have exploited these contexts in preference to the whole shell layers. This is probably because they took advantage of the increased levels of sedimentation, water retention and minerogenic compounds and decaying organic matter present in the crushed shell layers. Their presence in these layers would have helped provide internal support for the midden as a whole, increasing its stability. Decaying organic matter from contemporary and later root systems, however, will likely also have contributed to the composition of these layers. Consequently, the organic profile of these ancient surfaces could return a mixed signal. If this can be controlled for, the organic compounds they contain, such as lipids, hold considerable potential as repositories of environmental and anthropogenic information.

It has been recognised for more than a decade that such lipid biomarkers – organic molecules synthesised by living organisms and released into the environment by metabolic processes and decomposition – occur widely in archaeological deposits (e.g. Evershed et al., 1999). Recently, lipids preserved in chemically precipitated cave deposits such as stalagmites have been used successfully to interpret changes in climate and vegetation regime (e.g. Blyth et al., 2007; Xie et al., 2003); their use in the analysis of clastic cave sediments (comprising detrital grains eroded from land surfaces), though, is a much newer venture. A series of sub-samples was taken from all 16 of the contexts identified in the 2008 sample column at Hang Boi (figure 3) and have been analysed using gas chromatography – mass spectrometry at the Open University, UK. The results show that all of the samples contained a substantial and measurable plant biomarker component, including a significant number of plant derived compounds, including molecules typical of leaf waxes. Data interrogation to establish whether there are coherent trends through time is ongoing, as is the measurement of additional proxies such as compound specific carbon isotope analysis; however, initial results are promising and proof-of-concept is anticipated in the near future.

In sum, structurally, the midden may be conceived of as a series of gently sloping stable or semi-stable ground surfaces that were probably subject to periodic foot traffic, occasional low-energy water flow and increased natural sediment build-up courtesy of their exposure away from fresh and more rapidly accumulating camp waste deposits. We have yet to fully appreciate the impact of diagenetic processes, particularly water percolation through the midden, but also changes in its pH brought about by the presence of bat guano accumulation. As yet there is little indication of extensive diagenetic transformation leading to, for example, a complete loss of bone preservation; something that has been identified to exist in some cave sediments (e.g. Karkanas et al., 1999). We may anticipate, however, that the character of the deposits at Hang Boi will include an element of repetitive (as well as cumulative) post-depositional change linked to these alternating episodes of human activity and hiatus. Typified by the accumulation of the predominantly whole shell units, these periods of activity also introduced vertebrate faunal remains and other archaeological material. Although inherently unstable the inter-stratification of these with the more stable clay-silt/ crushed shell layers may have helped maintain the integrity of the midden, as probably did the flowstone deposit that capped it.

5. MIDDEN COMPOSITION

5.1 *Invertebrate fauna (molluscan and decapod remains)*

Examination of a sample of the molluscan remains from Hang Boi (see Rabett et al., 2009:94-97; table 3) has shown that *c*.98% of shells were land snails, *c*.91% belonging to two species: *Cyclophorus theodori* and *C. unicus*. Both these species are ground-dwelling forest herbivores. Low frequencies of other terrestrial snails, *Camaena* sp., *Odontartemon costulatus* and *Pupina* sp. were also identified (n=18/2239 MNI, or 0.8%), as were freshwater molluscs (*n*=21/2239 MNI, or 0.94%). These latter included the gastropods *Brotia* sp., *Angulyagra* (=*Viviparus*) *costatus* and *Melanoides tuberculata*, and bivalves including fragments of the large *Cristaria herculea*, the clam (*Corbicula* sp.) and freshwater mussel (Unionidae). Two further finds, a single instance of *Neritina* cf. *pulligera* and a fragment of *Cypraea* sp., have also been identified during excavation. Details of these are given in section 5.3 as both bear probable anthropogenic modification.

Four lines of evidence point towards the land snail component of this midden being of predominately anthropogenic origin (see Rabett et al., 2009:94-95). Firstly, the geological and current hydrological situation of the cave, together with the density of land snails within it, preclude them from being blown, washed or dropped into the cave. Secondly, although puncture marks do occur on a proportion of the recovered whole shells and partial non-human agency in accumulation cannot be completely ruled-out (see e.g. Stiner, 1999), the preponderance of whole specimens is inconsistent with what would be expected from natural snail predators, such as birds or rodents. Thirdly, although preliminary, our assessment of the snail taxa in the environments beyond the cave indicates local land snail diversity to be rich. Thus, this diversity, coupled with the relative natural levels of abundance of these taxa, contrasts markedly with the species dominance of *C. theodori* and *C. unicus* within the cave. Finally, the alternating stratigraphic pattern of the midden between whole and crushed land-snail layers, together with the presence of discrete patches of burnt shell, is a good indication that humans were the chief accumulators of this midden.

The precise method(s) by which these molluscs were consumed is less certain. As excavation has progressed we have found that the incidence of burnt fragmented and whole shells is a recurrent, if minor, site component; however we cannot say whether this is the result of a deliberate cooking practice or inadvertent burning of the midden substrate beneath camp fires. Discussions with locals (see Acknowledgements) indicate that although cyclophorids may occasionally appear on the menus of expensive restaurants in Vietnam today, they are more frequently collected mainly for medicinal purposes: to allay sinus ailments such as nose-bleeds. The current preferred method of preparation is by boiling (see Rabett et al., 2009:95 & 97); reportedly, with the dregs from rice wine-making added to the water to improve the taste. The flesh of the mollusc is removed with a small stick or skewer, with no need for any puncturing of the shell itself; a practice that is otherwise quite common when eating riverine gastropods, such as *Brotia* sp. in this region (e.g. Zuraina, 1994). The sheer volume of shells in the midden describes a much greater scale of consumption than can be attributed to medicinal acts alone, suggesting a previously more prominent subsistence role for these molluscs, though we maintain that boiling was probably the way that they were prepared in the past (Rabett et al., 2009:97). Such pre-ceramic boiling of molluscs has also been credited to foragers elsewhere in the world by the end of the Pleistocene (e.g. Miracle, 2002). In Southeast Asia, potential non-ceramic receptacles in which boiling could have taken place would have included large segments of bamboo or bottle gourds.

Order/Class	Family	Taxon	MNI	% MNI	NISP
Mollusca: Gastropoda	Neritidae	*Neritina* cf. *pulligera*	1	0.04	-
	Thiaridae	*Brotia* sp.	5	0.22	-
		Melanoides tuberculata	1	0.04	-
	Cyclophoridae	*Cyclophorus theodori*	1527	68.20	-
		Cyclophorus unicus	512	22.87	-
		Cyclophorus spp.	160	7.15	-
		Scabrina cf. *denudata*	1	0.04	-
	Vivaparidae	*Viviparus costatus*	5	0.22	-
	Pupinidae	*Pupina* sp.	1	0.04	-
	Cypraeidae	*Cypraea* sp.	1	0.04	-
	Streptaxidae	*Odontartemon costulatus*	1	0.04	-
	Camaenidae	*Camaena* sp.	16	0.71	-
Mollusca: Bivalvia	Corbiculidae	*Corbicula* sp.	4	0.18	-
	Unionidae	*Cristaria herculea*	1	0.04	-
		Unionidae spp.	4	0.18	
Decapoda	Potamidae	*Villopotamon* sp.	-	-	813
		Potamidae spp.	-	-	571
		TOTAL (MNI/NISP)	**2239**	**100.04**	**1384**

Table 3, identified invertebrate macro-faunal remains from the intact shell midden, Hang Boi, northern Vietnam (MNI = minimum number of individuals; NISP = number of identified specimens. Molluscan identifications after Abbot (1989); Nguyen Ngoc Thach (2005) and Webb (1948).

Another major component of the midden fauna at Hang Boi are the remains of freshwater crabs (comprising pereopod, chelae and carapace fragments), which are found in quantities at all levels of the excavation to-date. Identification of fixed and movable chelae sent to colleagues at the Raffles Museum of Biodiversity Research, University of Singapore (Rabett et al., 2009:97), suggested that almost all crab remains from the Upper Cave are from the same, recently defined, genus *Villopotamon* sp. (Family Potamidae; Yeo and Ng, 2007). Given the elevated location, the likelihood is that these crustacea were not self-introduced. The fact that a small proportion of these elements are also burnt lends credence to this conclusion, though for similar reasons, we cannot yet say if this was the result of deliberate cooking or was secondary to it.

5.2 *Vertebrate fauna*

The full range of identified non-molluscan fauna is presented in table 4. Detailed analysis and interpretation of the 2008 study sample is presented elsewhere (Rabett, *in review*); however, certain salient points may be made here. There is good reason to expect that some taxa represented, such as the bats and certain other small mammals (e.g. the common tree shrew, rat and possibly squirrel) are part of the naturally occurring fauna living in the cave or entering it from the nearby forest. Others, such as the black giant squirrel (*Ratufa (=Sciurus) bicolor*) and remains of snakes, birds and fish are more ambiguous in terms of their vectors of introduction, though predation by humans is probable, it can be not assumed in all cases. The majority of the larger mammals and reptiles, however, are likely to have been introduced as a result of human hunting activities. This contention is supported by the presence of butchery marks to chelonid, felid, suid, cervid and cercopithecid remains from the site. The frequency of such marks is small, but this owes much to the calcified state of many bone fragments. This preservation issue may also have biased the apparent frequency of burnt bone, which is also low, though some burnt bone has been recovered throughout the sequence. The range of taxa represented at Hang Boi is wide and appears to reflect changes through time, with the most intensive period of occupation occurring towards the end of the sequence (Rabett, *in review*). With the exception of monkeys, turtles and fish, however, most vertebrates occur in small numbers. This includes the remains of pigs (*Sus* sp.), which have been identified as a mainstay of subsistence elsewhere in the region (e.g. Piper et al., 2008).

Element representation among the small and intermediate-sized mammals (e.g. monkeys) shows that whole carcasses were likely being imported to the site for processing and consumption; as was also the case for turtles. The picture for large animals (cervids and suids) is more mixed. Extremities characterise the small number of deer and pig bones that have been recovered (both have been found with cut-marks, confirming butchery). With the deer, some limb and cranial elements also appear periodically. The current absence of meat-bearing bones among the pig remains could imply that either, these were never brought to the cave or that, if they were, such elements were subsequently removed after the carcass was butchered. Irrespective, the data are consistent with a model where transport decisions were a factor in procurement and thus in the deposition of vertebrate fauna into the midden.

Small and medium-sized carnivores also appear to have formed a minor part of the diet of foragers coming to Hang Boi (table 4). This subset of finds includes, notably, a partially charred fragment of *Panthera* cf. *pardus* 5th metatarsal from a basal context (5122). Although we cannot draw firm conclusions on the basis of this single specimen, it is one indicator that even during the period equivalent to the Younger Dryas stadial the local faunal community was sufficiently rich to support top predators like the leopard, and perhaps partly as a result of this the area continued to be attractive to humans.

The kind of occupation signature that the vertebrate faunal remains from Hang Boi provide is consistent with small-scale, varied and mostly opportunistic hunting during short-term sojourns at the site; one that may otherwise have been predominantly governed by reliable and probably seasonal (e.g. see Nguyen Viet, 2004) peaks in the availability of land snails and fresh water crabs – though, interestingly, without a corresponding emphasis on fresh water molluscs (see below).

Order/Class	Family	Taxon	Common name	NISP	%
Aves	-	-	Bird	16	2.64
	Pheasanidae	Pheasanidae spp.	Fowl	5	0.82
Mammalia	Bovidae	*Bos* sp.	Cattle	2	0.33
	Cercopithecidae	Cercopithecidae spp.	Monkey	71	11.70
		M. cf. *arctoides*	Stump-tail macaque	2	0.33
		M. cf. *assamensis*	Assamese macaque	1	0.16
		M. cf. *nemestrina*	Pig-tailed macaque	3	0.49
		M. cf. *mulatta*	Rhesus macaque	3	0.49
		Macaca sp.	Macaque sp.	7	1.15
	Cervidae	*Cervidae* sp.	Deer	64	10.54
	Emballonuridae	*Taphozous* sp.	Sheath-tailed bat	‡	0.00
	Felidae	*Felis* sp.	Cat	3	0.49
		Panthera cf. *pardus*	Leopard	1	0.16
	Hipposideridae	*Hipposideros diadema*	Diadem roundleaf bat	‡	0.00
	Hystricidae	*Hystricidae* spp.	Porcupine	3	0.49
	Miniopterinae	*Miniopterus* sp.	Bent-winged bat	‡	0.00
	Muridae	*Rattus* sp.	Rat	1	0.16
	Mustelidae	*Arctonyx collaris*	Hog badger	2	0.33
		Mustelidae spp.	Martens,weasels,badgers,otters	3	0.49
	Pteropodidae	*Rousettus* sp.	Fruit bat	3	0.49
	Rhinolophidae	*Rhinolophus* sp.	Horseshoe bat	‡	0.00
	Sciuridae	*Ratufa (=Sciurus) bicolor*	Black giant squirrel	2	0.33
		Sciuridae spp.	Squirrel	9	1.48
	Soricidae	Soricidae	Shrew	1	0.16
	Suidae	*Sus* sp.	Pig	23	3.79
	Tupaiidae	*Tupaia glis (=belangeri)*	Common tree shrew	1	0.16
	Viverridae	*Herpestes* sp.	Mongoose	1	0.16
		Paradoxurus hermaphroditus	Common palm civet	1	0.16
		Viverridae spp.	Civet	6	0.99
Pisces	-	-	Fish	217	35.75
Rajiformes	Dasyatidae	*Dasyatidae* spp.	Sting ray	1	0.16
Reptilia	Geoemydidae	*Cuora (=Pyxidea) mouhotii*	Keeled box turtle	6	0.99
		Cuora cf. *trifasciata*	Chinese three-striped box turtle	1	0.16
		Cuora sp.	Box turtle	5	0.82
		Cyclemys oldhami	Dark-throated leaf turtle	2	0.33
		Geoemydidae spp.	Hard-shelled turtle	14	2.31
	-	-	Snake	127	20.92
			TOTAL (NISP)	**607**	**100.00**

Table 4, identified vertebrate faunal remains from the intact shell midden, Hang Boi, northern Vietnam. ‡ Identified but not quantified.

5.3 *Material culture*

The occupation at Hang Boi is tentatively attributed to the local Hoabinhian cultural complex (for details of the Hoabinhian see e.g. Ha Van Tan, 1997; Nguyen Viet, 2000; Reynolds, 1990); however, no classic lithic forms (such as sumatraliths or short axes) have thus far been recovered. Indeed, the lithic assemblage is sparse – only 49 pieces from the 2007 sample (Rabett et al., 2009) and 31 from the 2008 excavation (table 5) were deemed to be of deliberate manufacture. Worked pebble tools are present and may have been carried to the site in a manufactured state, as no evidence of knapping micro-debitage has been recovered despite fine-gauge dry- and wet-sieving. Given that most identified flakes and cores were made on limestone, however, this does limit the chances of being able to confidently differentiate micro-debitage from naturally occurring fine rock-shatter, leaving the matter of on-site manufacture unresolved. Flakes make up the majority of the identified lithics from 2007 and 2008: n=34/49 and n=19/31. They show evidence of hard hammer reduction; they are un-retouched and show few signs of use wear, though edge damage indicative of trampling is present on some pieces. A small number of artefacts (n=4) have been identified as blade-like flakes. This includes two probable burin spalls (table 5, nos. 28 and 30), suggestive that some manufacturing activities – possibly bone working – did take place at the site. The few cores recovered (n=5) have in all but one questionable instance a single platform (i.e. flakes were only struck from one end). Finally, one small secondary flake (table 5, no. 20) recovered from near the top of the sequence has a very regularised and burnished cortical surface. This piece stands out from the rest of the assemblage and in all likelihood came from a polished stone tool. Overall, the assemblage indicates low levels of activity, with no significant on-site re-tooling and expedient or un-sustained tool use.

Verifiable bone tools have not so far been recovered from any contexts in the Hang Boi midden, although one bone fragment from context (5103) exhibits several areas of deliberate modification, seemingly centred on the creation of longitudinal furrows in the bone associated with longitudinal fine-grained striae. Indications are that this piece is a manufacturing off-cut, which provides circumstantial evidence that some form of bone-working activity may have taken place on-site and complements the burin evidence, although the worked bone comes from a much later period of site-use.

Only two modified shells – the *Neritina* cf. *pulligera* and *Cypraea* sp. described above – have been found at the site. The posterior portion of the *Neritina* has been clearly ground, slightly reducing the overall length of this small shell to 13.83 mm. This procedure would have thinned the shell sufficiently for it then to be punch-struck to create a perforation. This piece has been provisionally identified as a bead, though the lack of pronounced wear to the inner rim of the hole suggests it may not have been strung. The *Cypraea* is more fragmentary, making the distinction between percussive working and natural breakage, or breakage for meat extraction, one that is difficult to judge conclusively. There are patches of colouration on the shell, suggesting that it may have once been pigmented. Irrespective of its modification history, its presence in the site assemblage is significant as, with the possible exception of a single small fragment of sting-ray (*Dasyatidae* spp.) spine from context (5010), it is presently the only verified example of a maritime species appearing at Hang Boi. The possibility of it being worked is also in-line with occurrences of modified marine shells at other inland Hoabinhian sites in Vietnam (Nguyen Lan Cuong, 2007; Reynolds, 1990:14).

A handful of glazed ware sherds have been identified during excavation of the upper-most contexts in the midden. These are almost certainly intrusive, given that all

No.	Grid-Square	Context No.	Object metrics (mm)			Material	Description
			Length	Width	Thickness		
1	226/108	5111	47.82	55.14	77.86	Limestone pebble	Single platform flake core. 4 removals; sheen on part of surface and poss groove for sharpening
2	226/108	5111	68.65	28.81	28.42	Limestone	Possible flake fragment with red powdery residue
3	226/108	5111	102.34	79.30	52.67	Limestone	Natural utilised stone fragment - possibly for grinding red powdery pigment
4	226/109	5107	22.35	22.32	4.45	Limestone	Flake with crushed platform (edge damage, probably from trampling)
5	226/109	5107	13.94	21.71	5.00	Limestone	Flake with plain platform (edge damage, probably from trample)
6	226/108	5108	31.00	50.13	13.00	Limestone	Flake with large plain platform
7	226/109	5107	121.06	111.53	32.69	Limestone	Flaked tabular piece with possible opposed platforms - 3 removals one end, 1 removal other end.
8	226/109	5108	100.57	74.29	18.07	Limestone	Natural utilised stone fragment - possibly for grinding red powdery pigment
9	226/109	5108	23.37	17.57	5.07	Limestone pebble	Flake with a plain platform, possibly from a cobble source
10	227/107	5103	42.07	23.83	9.54	Limestone	A blade-flake with lot of crushing along one edge
11	227/107	5103	23.41	30.44	17.10	Limestone	A plain platformed flake.
12	227/107	5101/5102	15.76	34.58	7.50	Limestone	A distal flake fragment
13	227/108	5106-5108	24.90	60.84	50.99	Limestone	Shattered fragment that has been flaked - possible core
14	227/107	5100	17.24	52.52	29.77	Limestone pebble	Single platform pebble core, 3 flakes removed
15	227/108	5109	38.13	24.69	10.03	Limestone	Possible secondary flake with plain platform
16	227/108	5103	24.86	16.66	6.17	Limestone pebble	Crushed platform limestone siret flake
17	227/108	5103	22.69	28.77	6.55	Limestone	Crushed platform flake (not from pebble)
18	227/108	5102	20.76	23.03	5.19	Limestone	Flake with broken platform
19	227/108	5102	25.72	28.69	7.46	Limestone	Plain platformed flake
20	227/107	5101	28.71	22.90	5.68	?	Secondary flake with cortical platform; smooth, polished surface, probably from polished stone tool
21	227/107	5101	36.29	38.58	12.45	Limestone	Distal secondary flake fragment
22	227/108	5100	27.62	35.04	8.65	Limestone	Plain platformed flake
23	227/108	5105	25.22	26.25	10.65	Limestone	Cortical platformed flake with edge-crushing, probably from trample
24	227/108	5105	14.15	20.04	3.12	Limestone	Distal flake fragment
25	227/108	5105	46.78	57.06	23.35	Limestone	Plain platformed flake
26	DSW	5123	12.82	28.39	5.99	Limestone	Crushed platformed flake
27	DSW	5127	44.68	64.05	30.53	Limestone	Single platform core, with at least 5 flake removals, probably burnt
28	DSW	5120	39.72	9.44	10.09	Limestone	Crushed platformed bladelet, burin spall, removing an earlier burin.
29	DSW	5127	31.97	29.48	11.22	Limestone	Crushed platformed flake
30	DSW	5114	31.63	12.91	9.62	Limestone	Crushed platformed bladelet, flake (possible burin spall)
31	DSW	5126	41.54	18.31	4.63	Limestone pebble	Distal primary blade fragment with edge damage, probably from trample.

Table 4, lithics identified from the 2008 excavated sample.

excavated deposits in the upper cave sequence are of pre-ceramic age, though their presence does suggest that minor vertical movement of materials has occurred in the midden.

5.4 Evidence of burning

Fragments of charcoal and small quantities of burnt bone and shell are found throughout the midden sequence at Hang Boi; a particular concentration of burnt material appears in context (5127) at the current bottom of the excavation. Two other such areas have been identified. The clearest of these is seen in section as context (5112) – figures 5 and 6. This depositional lens consisted of a discrete area of burnt crushed shell, bone and large fragments of charcoal *c*.30 cm in diameter. On present evidence it is perhaps more likely to be a dump of burnt material rather than a hearth as there is no clear indication of *in-situ* burning to the sediment or presence of containment features, such as cobbles. There is, though, a clear colour difference between this light grey/white lens and the surrounding layers. As with the faunal and material cultural evidence, the evidence of burning supports the contention that human activity was the major source of midden accumulation. Taken together these data suggest that occupations were short-term and probably involved comparatively few individuals. How their activities would have combined with post-depositional processes in the incremental development of the shell midden here is the next matter to address.

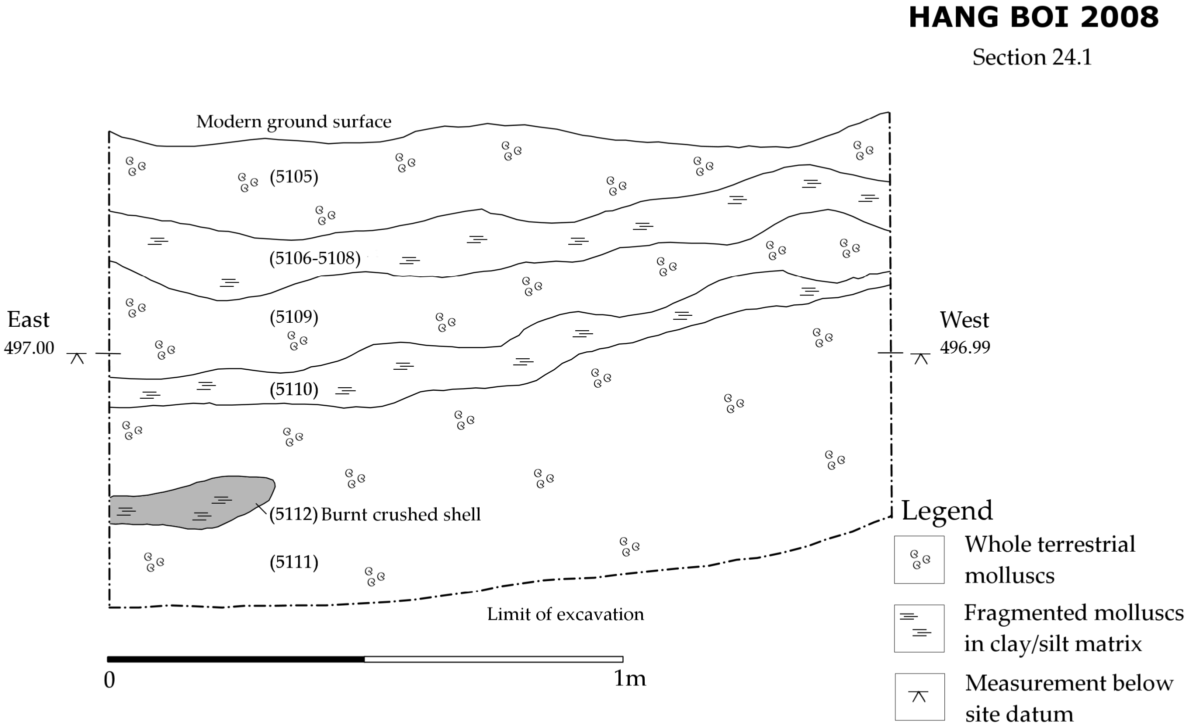

Figure 5, contexts in the north-facing section of sq.226/108 and 227/108, section 24.1 (Trench 1), including a discrete lens of burnt crushed shell – probably a hearth dump – from the Upper Cave midden, Hang Boi. Edges of excavation are given as parallel here, but in the field they were sloped to prevent section-collapse. (Drawing by L.Farr, reproduced for publication by R.Rabett.)

Figure 6, photograph showing the crushed burnt shell and ashy context (5112), section 24.1, Trench 1, Upper Cave, Hang Boi. (Photograph: R.Rabett.)

6. DISCUSSION

Establishing a detailed and dynamic picture of site-formation processes at Hang Boi is a crucial step in understanding the site's position within the wider context of early hunter-gatherer mobility at the end of the last glacial – a central research aim of this project.

The large accumulations of land snail shells that form the principal structural component of the surviving midden are almost certainly the result of deliberate selection: people consistently harvested two species out of a range of potential terrestrial and aquatic mollusc resources that are likely to have been available in the cave's general vicinity. Although there are changes in the vertebrate faunal composition through the sequence, and despite significant changes in the regional landscape from a lowland riverine setting to coastal conditions during the site's history (e.g. see Tanabe et al., 2006), we see no evidence for a major shift in the collection of molluscan fauna. This situation leaves us to ponder the site's role within a settlement system, especially given that by the mid-Holocene at sites like Da But, communities were clearly practicing a mixed marine-inland economy. The AAR dates on the cemented shell remnants suggest that people were still coming to the site after *c.*10.6 cal. ka BP.

The most intensive phase of occupation is towards the top of the surviving midden and dates to between 11,400±108 cal. BP (UBA-10166) to 10,631±58 cal. BP (UBA-10163). Based on sediment core data 29.5 km to the northeast of Hang Boi, Tanabe et al. (2003a, 2003b, 2006), *c.*11.6 to 10.2 cal. ka BP the landscape within this 30 km radius would have been made up of salt marsh and lagoon habitats. These environments do not appear to have been exploited by people when they were visiting Hang Boi at this time. We offer four possible explanations for this.

6.1 *Differential transportation*

The first possible scenario relates to differential transportation of resources from point of procurement to point of consumption. Although there is no clear consensus about what should constitute an 'effective foraging radius', a study of 14 tropical ethnographic groups, indicates that the range of daily forays from residential camps is 2-10 km Shoocongdej (1996, table 2.7). If trips are more targeted or 'logistical' is nature (*sensu.* Binford, 1980), involving same-day, over-night or multiple-day forays, these distances ranged from 3.2 km to as much as 30 km (Shoocongdej, 1996 table 2.8). On this evidence, access to the coast from Hang Boi was feasible on a regular basis; however, transportation costs would be expected to increase with increasing distance from the point of acquisition to a residential camp.

One ethnoarchaeological study into the movement of collected marine molluscs in the Torres Strait, Australia (Bird et al., 2002) concluded that under circumstances where procurement and consumption locales are separated, biases in faunal representation will occur in site assemblages. This is because bulk material (i.e. shell) may already have been discarded *en route* to a consumption or residential site. With reference to the Californian coast, Cook (1946:51) has also reported that while some molluscs were transported 'in the shell' by native groups, 'the far more economical and efficient method was to export only the dried meats'. Finally, Erlandson (2001) has suggested that a coastal zone of exploitation should be tied to the distance that a group may travel in a day in order to collect food, i.e. 5-10 km; Claassen (1998:43) quotes a distance of *c.*11 km, based on a long-term ethnographic study along the coast of South Africa. From these lines of evidence we might expect that procurement forays to the coastal salt marshes and lagoons of the palaeo- Song Hong River (Red River) from Hang Boi would have taken more than one day and may have involved the transportation of shell fish meats rather than whole molluscs back inland. Both this scenario and the distance involved could potentially have introduced a significant bias into the composition of the Hang Boi midden, if people were basing themselves here while exploiting coastal resources.

While the transportation of some coastal species could have been affected by such a molluscan 'schlepp effect' (after Daly, 1969), the shells of other species included in the study by Bird et al. (2002) (such as neritids) were found to be carried as far as *c.*5 km inland. Research from other parts of the world (e.g. Ceci, 1984) also indicates that marine shell deposits are not necessarily restricted to the vicinity of the coast. Even allowing for the impact of transportation costs and the possibility of over-night camps *en route* from the coast to the site, we might expect to find that at least a small proportion of the midden make-up would include maritime molluscs. Shell analysis at Hang Boi is on-going, but at present this does not appear to have been the case. Contact with the coast is indicated through the fragment of cowrie that has been found. Similar evidence from elsewhere in the region (e.g. Endicott and Bellwood, 1991; Nguyen Lan Cuong, 2007) suggests that there was a practice of importing marine shell as cultural artefacts either through direct procurement or through an early exchange system.

Where the schlepp-effect argument may have greater credence is in the exploitation of freshwater molluscs at Hang Boi, as these *do* occur at low frequencies within the midden. It is conceivable that some form of selective transportation of the freshwater resources (crabs, fish and chelonids) resulted in a predominant importation of freshwater mollusc meat rather than shell.

6.2 *Subsistence orientation*

The second scenario that might explain the situation at Hang Boi relies on current understanding about the location of Hoabinhian sites. Despite apparent coastal occurrences elsewhere in the region, those in Vietnam are characteristically an inland phenomenon. Ha Van Tan (1997) reports that only a single site (out of more than one hundred) that is dated to

5,184±110 cal. BP has a maritime orientation: Bau Du. This is an open-air site, currently 4 km from the coast in Quang Nam Da Nang province. It is possible that Hoabinhian subsistence was broadly geared towards the exploitation of purely inland resources. This illustrates that proximity to coastal resources does not automatically mean they are immediately adopted and become pre-eminent in forager economies, as the work of Szabó et al. (2003) has demonstrated.

6.3 *Habitat productivity*

A third explanation for the absence of maritime resources at Hang Boi is that local shoreline exploitation was simply not economic. The productivity of maritime habitats would have been strongly linked to the rate of coastal inundation. Only once the rate of sea-level rise had slowed did these habitats, particularly the mangrove forests that developed across Ninh Bình (Tanabe et al., 2003a), become more firmly established, forming sediment traps and raising biological productivity (e.g. see Gonzalez and Dupont, 2009). Woodroffe (1990) calculated that inundation rates exceeding *c.*0.8-1 mm/year (0.08-0.1 m/100yrs) tends to preclude mangrove development. During the latter period of midden accumulation at Hang Boi, from 11,400±108 cal. bp (UBA-10166) to 10,631±58 cal. bp (UBA-10163), sea levels rose from about -33 m to -25 m, or *c.*1.04 m per/100 years, possibly hampering mangrove forest growth. Mangroves appear in the vicinity of the Tráng An massif *c.*9 cal. ka BP and persisted until *c.*6 cal. ka BP under stable coastal conditions (Tanabe et al., 2003a). It is possible that this environment did not become productive enough to support local economies until after *c.*9 cal. ka BP. Although our AAR analysis of the cemented midden remnants could not provide absolute dates, the relative sequence identified from the samples is likely to be reliable and strongly suggest that people were still coming to the cave after *c.*10.6 cal. ka BP. The composition of the Holocene midden remnants has not been studied in detail, but an increase in local mangrove productivity might have featured in the eventual abandonment of the site for a more accessible lowland setting.

6.4 *Seasonality*

Finally, we return to the proposed periodicity of occupation at Hang Boi. Nguyen Viet (2004) has indicated that cyclophorids are still actively collected during the wet season (April-October) in Vietnam. Under this scenario, marine resources may have been collected and consumed at a different time of the year and at a separate location. Future isotopic analysis of the land snails at the site should help determine if such a prevailing seasonal signature exists in the formation process of the midden.

Many modern small-scale forest communities in Southeast Asia are known to practice mixed economic systems that emphasise particular resources at different times depending on schedules of availability (e.g. Eder 1984; Endicott 1984; Griffin 1985; Sellato 2007). While one cannot ignore the historical and economic contingencies of this arrangement, it is possible that it is a contemporary expression of a much older principle. Economic flexibility ensures subsistence needs are met and provides effective risk management in the characteristically heterogeneous environments of the low latitudes tropics.

The per-carcass-unit contribution of larger animals to forager diet will have been greater than that of smaller animals even if they are less frequently represented; however, this should not automatically persuade us into thinking that larger animals governed either the cause or timing of occupation at Hang Boi, nor that land snails were a secondary resource. The great availability of *C. theodori* and *C. unicus* may have been a key attractor that drew people to this location and others like it in the sub-coastal uplands during the wet season. Their appearance in the cemented midden remnants suggests that this practice persisted, at least for a period, even when marine resources were close by. Analysis of element representation for vertebrate fauna also suggests that whereas intermediate-sized animals, such as monkeys and turtles, were probably being brought back to the cave as whole carcasses, the same cannot be said of larger ungulates, with only certain body units of which being deposited at the cave. Botanical remains (nuts and seeds) have also been recovered from the midden deposits at Hang Boi, signalling that there is an additional stratum of subsistence still to be incorporated into this picture, as demonstrated by Nguyen Viet for other northern Vietnamese Hoabinian sites (Nguyen Viet, 2008). In essence, according to this seasonality scenario, land snails provided a reliable local staple that was supplemented by resources from a range of local freshwater and terrestrial habitats. Some of these forays involved trips of sufficient distance to warrant either the setting up of over-night camps or at least off-site processing. Either situation could have resulted in the low signature of freshwater molluscs in the midden.

At the present time, each of these four propositions has its merits, though, none yet stands out as the more likely, and other alternatives or a combination of these scenarios may still emerge as the best fit to the data. The low levels of freshwater molluscs (as opposed to other resources from this habitat zone) could simply reflect the fact that such molluscs, like resources along the coast, were simply not targeted. The lack of coastal fauna might indicate the existence of an adaptive 'time-lag' between the appearance of a new resource environment and its integration into local subsistence practices. Similar situations are noted elsewhere in Island Southeast Asia – for example at Gua Balambangan, East Malaysia and Tabon Cave, in the Philippines (Fox, 1970; Zuraina et al., 1998) – lend support to this notion. The fact that a single shell midden can inspire such a variety of interpretative readings highlights the degree of settlement and subsistence complexity such sites still have to offer.

7. CONCLUSION

The following conclusions can be drawn regarding the evidence from Hang Boi. Hunting and gathering activities conducted from this site appear to have focused on exploiting local resources (land snails) possibly during annual peaks in their availability. Whilst camping here people also ranged some distance further afield, perhaps employing a more opportunistic procurement strategem, to supplement returns from this staple. The periods when humans were absent from the site were of sufficient length for observable differences in sedimentation to occur between the more stable and compacted crushed shell layers and the less stable whole shell deposits. Some were also long enough for disturbance-sensitive fauna, such as fruit bats, to begin using the cave. The higher clay component in the lower half of the midden may be partly due to water action or percolation, though water table saturation can be ruled out. Coupled with a reduction in the diversity of recovered vertebrate fauna during the period equivalent to the Younger Dryas, it looks likely that there was a lower frequency of visits during this period compared to later in the site record, though this does not seem to have demonstrably altered land snail collection strategies.

Aside from changes in the intensity of occupation, we cannot say that there have been notable shifts in site function across the Pleistocene-Holocene transition either. We have yet to determine if changes occurred at the site during its Holocene occupation, though initial indications suggest that cyclophorids continued to be a dominant feature of midden accumulation. This raises intriguing possibilities for settlement reconstruction. Either, people bearing Dabutian ceramics – as indicated from pottery finds in the Lower Cave at Hang Boi – were visiting the site to exploit inland resources and then returning to the coast, or such ceramics were exchanged with coastal Dabutian communities by inland Hoabinhian ones. Either way, the likely existence of Holocene occupation at Hang Boi implies that activities carried here formed part of a wider subsistence system that probably included coastal communities.

The absence of evident coastal exploitation from the surviving Pleistocene-Holocene shell midden, even when such environments existed in the vicinity of the site, has still to be resolved. There is a strong possibility that occupation was seasonal in nature and that the land snail harvesting, which took place here, was one element of diverse economy that would have included spells of hunting and collecting in other more distant locations out in the landscape, possibly including coastal habitats, as cultural links to these do appear to exist. Forthcoming work within Tràng An by the TAAP will hopefully begin to resolve this matter further by assessing the role of this site in relation to others in the same general locality.

In this paper we have tried to highlight the value of land snail midden analysis and in so doing contribute in the movement away from normative use of the term 'shell midden'. Our findings from Hang Boi suggest that this particular site is perhaps most accurately described as a 'shell-bearing midden camp' – following Widmer's (1989) nomenclature. The deposits, though dominated by land snail shells, also contain the remains of other invertebrate, as well as many vertebrate and botanical remains; species representation, as well as evidence of butchery and burning, confirms that various human activities took place here. The 'camp' descriptor recognises that human occupancy was probably periodic; making people the primary but not sole source of material entering the cave or the midden. Hang Boi represents only one of more than a hundred such inland shell midden sites in northern Vietnam alone. It is widely known that the species of mollusc making up these middens differs from site to site. We anticipate that this is only a hint of the inter-site variability that exists and that a great deal about Hoabinhian settlement and economy is still to be learned.

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