SUNDASIA FIELD REPORT

(4-24th September 2017)

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1. OBJECTIVES

The fourth field season of the SUNDASIA Project has been the first to pursue research programmes across all of its principal work packages in archaeology, GIS and digital terrain mapping, chronometric and palaeoenvironmental reconstruction, with further steps also made in both management field training and conservation. There were six objectives for this season, to be met through the efforts of the largest field-team to-date (22 people – including three doctoral and five undergraduate students).

The first objective of the season involved continuation of the landscape survey and mapping programme (sites, locales and marine features), which commenced in March/April this year; now with the aid of a SUAV (Small Unmanned Aerial Vehicle) – or 'drone' – to produce photogrammetric landscape imagery (at *c*. 220 m altitude). As part of this work, for the first time, all locations of interest, project activities, and project-related activities were logged using a standardised alpha-numeric identification system for entry and manipulation within a GIS database environment.

From an archaeological perspective our intention, and second objective, was to return to Hang Thung Binh 1 to continue excavation in Trench 1 in light of the unexpected antiquity of cultural material excavated from here in March/April of this year; and to open a new complementary trench. This work – including obtaining data on magnetic susceptibility (for a student dissertation) – was intended to take place during the first half of the season, with excavation shifting in the latter half of the season to another site – also identified in March/April 2017 as having promising archaeological potential earlier this year: Hang Trau Bai Dinh. In the event, excavations were confined to Hang Thung Binh 1.

Use of the GIS unique identifier system extended to the third and fourth of our objectives. Field collection of modern cyclophorids was undertaken from a range of geographic settings around the massif, completing principal coverage of baseline shell data needed for carbon off-set analysis – and beginning establishment of a local calibration curve for terrestrial shell dating. Sites in our palaeoenvironmental programme (i.e. where pollen traps for modern comparative pollen samples have been situated and

where prospective sedimentological hand-coring has been undertaken) were also allocated identifiers under the same system.

The fifth objective for the season centred on the Project's ongoing commitment to aligning archaeological and conservation ambitions in data-collection. To this end a series of eight infrared, motion-sensitive trail cameras were to be placed within a stretch of forest in the core zone least affected by infrastructure, disturbance and visitation. From a conservation perspective this would begin the process of assessing the current state of non-arboreal vertebrate biodiversity within Tràng An; archaeologically, this work would provide a valuable point of comparison to the extensive zooarchaeological remains being recovered in excavation. In addition, and as part of another student dissertation, we continued field-collection of small vertebrate remains (comprising deadfall, and owl pellet contents) from the site of Hang Ang Noi. This cave is located within the core zone, at an interface between the park's undeveloped interior and one of its arterial access routes, making it an excellent marker-site for tracking changes in species representation, and through this any disturbance in resident fauna.

Capacity building and knowledge exchange are central to the ambitions of the SUNDASIA Project. The sixth and final objective for this season has been to develop these ambitions through continued direct involvement of Tràng An Management Board staff in all aspects of fieldwork; as well as direct collaboration and mutual exchange of knowledge with key Vietnamese institutions and researchers.

2. LANDSCAPE SURVEY (GPS & DRONE COVERAGE)

Digital elevation models are an essential component in any GIS based archaeological and ecological landscape assessment. The absence of such model has sparked the development of alternative methods to create a detailed model of as a large a section of Tràng An as possible. Using structure from motion (sfm) technology and small unmanned aerial vehicles (UAV) to create 3D models, DEM and orthophotographs of Trang An WHS is a challenge for the sophisticated equipment employed, not least due to the parks dimensions but also because of its extreme topography, dense vegetation and tropical climate. This fieldwork season was dominated by testing new equipment brought into the field and gathering data to develop a methodology for future UAV surveys.

2.1 *Objectives*

- □ Survey a sample of Trang representative of its topography and create DEM and orthorectified photographs
- □ Train Trang An Management Board staff in UAV based sfm techniques
- □ Create 3D models of trenches in Hang Thung Binh 1
- □ Survey recorded and new erosional notch sites
- □ Explore landscape for unrecorded cave site

2.2 *Training*

Queen's University Belfast undergraduate students Aaron Redmond, Ciaran Kelly, Emilie Green and Meghan McAllister and Trang An Management Board members Le Thi Thanh Kim Hue and Lie received introductory training to UAV use (figure 1), structure from motion technology, survey methods (GNSS and total station) and data processing using Agisoft Photoscan. A full training day was allocated at the beginning of the season, followed

by three afternoon sessions during which data processing was demonstrated. Meghan McAllister and Le Thi Thanh Kim Hue also had the opportunity to fly the UAV on the hotel grounds. Apart from flight training, all students and Management Board members actively participated in fieldwork where they could get practical experience in conducting UAV surveys.

2.3 *Survey area*s

Seven areas in the Tràng An WHS core and buffer zones were surveyed. The Bai Dinh Hotel site was used as a training site to demonstrate to students the full process of the structure from motion method. The Luon and Van rivers site was surveyed as a high-altitude survey test over a large area. The data was made available to doctoral candidate Vo Thuy for use in her research on the history of the ancient capitol Hoa Lu.

The Thung Binh and Hang Hanh were selected because of the archaeological sites they contain, both excavated as part of the SUNDASIA project. SFM surveys of Hang Thung Binh 1 and excavation trenches at Hang Hanh were already scanned during previous seasons and the UAV surveys add to the creation of a complete 3D record of the entire sites and surrounds. An island close to the Visitor Centre was also surveyed.

Zone 3 Doline and Thai Vy Temples were selected because of their diverse topography, which made them viable targets to test how well SFM works in high relief landscapes. Both areas comprise several peaks of up 190m height, steep slopes, vertical cliffs with adjacent flat land. Thai Vy was found to be almost completely flooded as a result of recent and unusually strong monsoon rain, making much of the flat lands impassable. Much of the mountains in this area feature tall vertical cliffs, which are common in the eastern part of the Trang An proper. The Zone 3 Doline is representative of the western section of the proper, which is dominated by self-covered karst terrain. Thai Vy temple is also located within a zone for which a LiDAR survey exists. Procurement of the data would allow for a side-by-side comparison of DEM derived from either platform.

2.4 *Equipmen*t

- Leica GS15 GNSS NRTK for measuring ground control points (gcp)
- Mavic Pro UAV plus controller
- 4 batteries
- GPS emergency tracker for UAV recovery
- iPad Pro

The DroneDeploy app for iOS and its web equivalent were used to plan and conduct the survey in autonomous flight mode. The drone autonomously returned home for battery change and resumed its mission at the last recorded waypoint. Photoscan Pro was used to create initial models to ensure that image quality and overlap were sufficient for model generation. All models will be fully processed in Belfast at Queen's University.

GCP were cut out of orange 1x1 m tarpaulin squares and marked with black duct tape to indicate the target center. Ground tests were carried out to ensure that targets were visible from up to 250m. GCP were set at all sites except for Zone 3 Doline due to technical issues with the GNSS data collector and time limitations. The amount of available loci to set out tragets was limited due to flooding of many of the survey areas. Other suitable topographical features were used instead where available.

Figure 1: Drone in flight outside Hang Thung Binh 1 (photo: R. Rabett).

Ground Control Points (GCP) were cut out of orange 1x1 m tarpaulin squares and marked with black duct tape to indicate the target centre. Ground tests were carried out to ensure that targets were visible from up to 250m. GCP were set at all sites except for Zone 3 Doline due to technical issues with the GNSS data collector and time limitations. The amount of available loci to set out tragets was limited due to flooding of many of the survey areas. Other suitable topographical features were used instead where available.

All surveys could be completed with a single battery except for Thai Vy temple, which required 2 batteries, and Zone 3 Doline, which required 3 batteries. Each battery allows for a maximum flight time of 20min including take off, flight to starting point, survey, return and landing.

Initially the maximum flying altitude for all surveys was set at 250m, to keep the UAV clear of the highest peaks in Trang An. However, the maximum altitude had to be increased by 50m to compensate for errors in data processing that was caused by extreme differences in elevation between the karst peaks and valley floor.

The total surveyed area is 265.6 ha, which was surveyed at flying altitudes of 160 to 300 m depending on the highest peak in the covered area (table 1, figure 2). Only the training survey of Bai Dinh Hotel was flown at a lower altitude of 80 m. Greatest distance to the UAV was 1.5 km during the Zone 3 Doline survey. Permission to fly over the selected areas at stated elevations were granted by the Trang An Management Board.

Site name	Map grid	area (ha)	Alt (m)	Resolution (cm/px)
Hang Hanh	3C	4	100	2.7
Luon and Van rivers	4C	50	200	8.9
Lengur Island	3B	9.6	150	4.8
Thai Vy temple	3C/4C	56	300	8.9
Zone 3 Doline	2B/2C	120	300	8.3

Thung Binh	2B/2C	22	250	n/a
Bai Dinh Hotel	2B	4	80	n/a
	Total	**265.6**		

Table 1: Overview of surveyed areas.

Surveying flooded areas resulted in photographs with largeportions of non-structured content. This caused errors in the model but did not seem to influence land areas. Particularly Hang Hanh suffered from this effect, as it was surrounded by water at the time of the survey. As a precaution against model failure, a series of oblique photographs circulating Hang Hanh hill were taken.

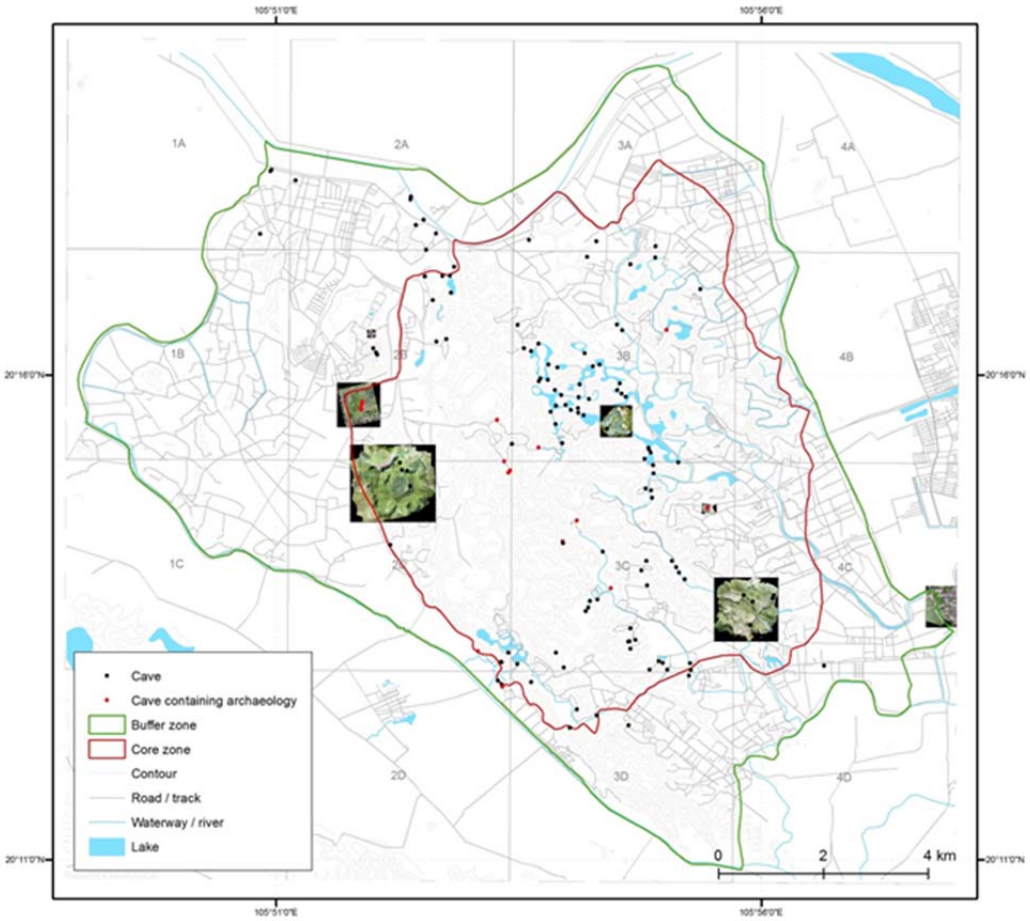

Figure 2: Map overview of season outcomes.

2.5 Erosional notch survey

As a result of the March 2016 workshop, Dr Van and Dr Trung supported my suggestion to survey further erosional notches in Tràng An to refine the current model. Along with a refined DEM, the coast line that was present in Tràng An during past sea transgressions, particularly during the middle Holocene can be modelled in greater detail. Material used:

- □ Leica GS15 NRTK GNSS
- □ Leica TS06 total station

Several control stations were surveyed with the GNSS that were used to orient the total station (TS). Using reflectorless mode, points along the notch were measured directly within cm accuracy. Data is processed at Queen's University Belfast. Erosional notches were surveyed at six locations in sectors 3B, 4B, 2C and 4C. The majority of those were surveyed to obtain a calibration set to match notch elevations with the survey undertaken by VIGMR in 2012. One new notch site was surveyed at Hang Hop and five notches could be surveyed from a single location near Thai Vy temple in sector 4C. Two scheduled sites could not be surveyed due to flooding of the target areas. The west of the park was partially searched for notch sites, but none were located. Locals that were asked were not aware of the presence of any erosional notches in the area (figure 3).

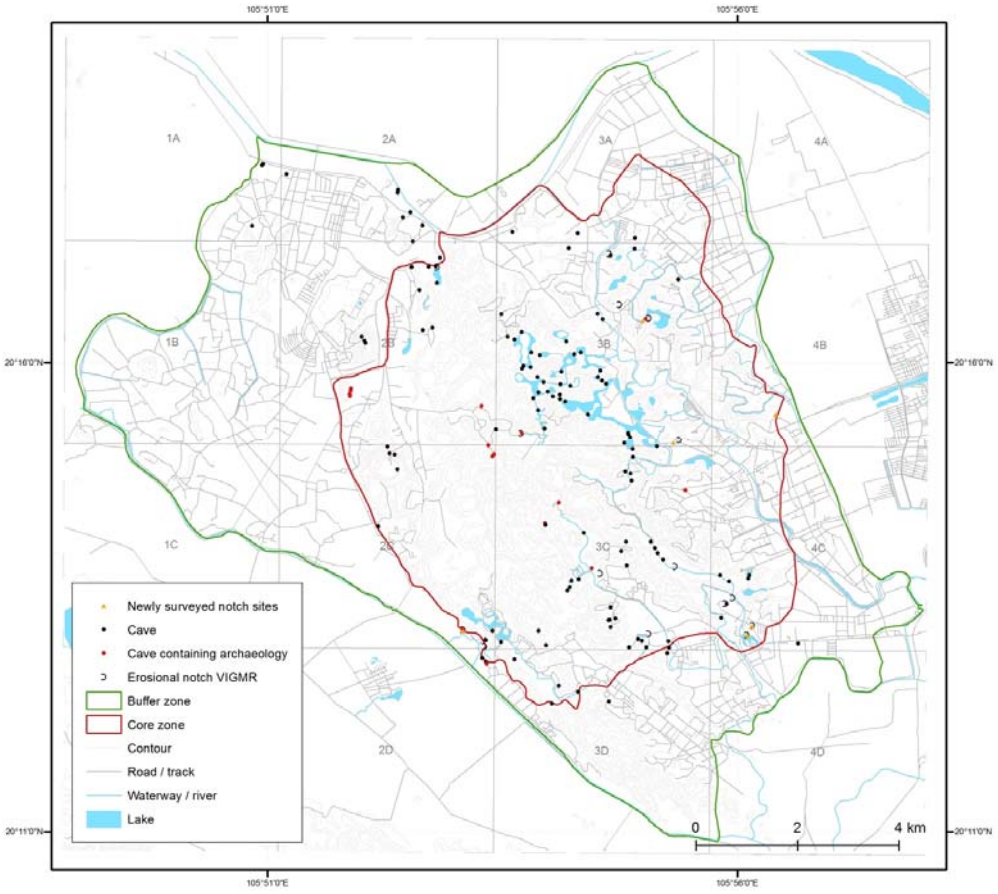

Figure 3: Erosional notch sites surveyed by VIGMR and SUNDASIA.

2.6 *Cave sites*

Planned expeditions to locate more unrecorded caves could not be carried out because UAV surveys took more time than panned. The cause for the delays were due to technical issues with some of the equipment, which required more time in the field. NRTK was not available at all locations, which meant that individual GCP had to be recorded for a longer period and post-processed in Leica GeoOffice. Failure of the UAV to accurately autofocus when controlled by third-party-apps required re-surveys and partial re-surveys of Thung Binh and Zone 3 Doline. This error is known to DJI and DroneDeploy and a solution is under

development. Other time limiting factors were provision of training and a typhoon that grounded field work for two days.

However, during our survey missions, we were told by local men about two caves that are not recorded in the cave inventory. Zone 3 Cave or Cuba Cave, is allegedly a small opening near the ground that leads into a larger chamber that extends for some distance. The cave was inaccessible at the time of visit because the cave carries water during the rainy season. The second cave, Hang Thung Binh 6, is allegedly located on the west facing side of Thung Binh, just above the old quarry site. The cave has a vertical entrance and can be accessed only with a rope. I hope to explore the cave during the November season.

Additionally, to the two caves, an interesting rock shelter was discovered during a flight to assess Hang Hop for sediments and access. The rock shelter is located near the top of the hill that hosts Hop Cave and can be reached with some effort. Ascending to the cave requires small minor scrambles up low ledges. The final ledge, *c*. 5m below the destination, was *c*. 2 m high. Only one location where the ledge has eroded away was passable but unfortunately, wasps occupied the area and the team had to descend emptyhanded.

A sfm survey was carried out at the three trenches in Hang Thung Binh 1. Trench 1 and the Archaeological institute's trench were surveyed during the March season. A section was cleaned in the institute's trench and trench 1 was extended vertically and both needed re-survey. 12bit encoded targets were used as control points and surveyed with the TS06 total station. The trenches were systematically photographed from various angles using a full frame Canon 6D and speedlite. This ensured that every part of each trench was recorded and evenly lit. Initial models show good results and final processing is undertaken at Queen's University Belfast.

3. HANG THUNG BINH 1

3.1 Archaeological excavation of Trench 2

Following the unexpected antiquity of the upper chamber deposits at Thung Binh 1, we were keen to return to this site to continue work in the same trench and try and establish the relationship between our excavation and the sequence revealed in the Institute trench at the back of the main chamber, which had been accorded an age in the range of 3000-6000 uncal. BP, based on artefacts recovered (Su *et al*. 2012, Su & Tuấn 2012). With this in mind, and drawing on our own geophysical survey of the site (Green n.d.), we laid out a new 2 x 2 m trench following the grid system we had established for the cave surface area in March/April 2017 (150/243, 151/243, 150/244 and 151/244) near to the mouth of the main chamber (figure 4). Initially, excavation was confined to squares 150/243 and 244 on the inner side of the trench. The surface context (E900) was completely modern and lifted without sieving. The first subsurface context (E901) contained frequent angular/sub-angular limestone clasts and a moderate frequency of larger (*c*. 10 cm) limestone fragments, with moderate evidence of burnt (dark grey) limestone fragments appearing in 150/244. A small area of dark sediment, with reddened burnt sediment beneath, started to appear in the southern part of 150/243, which extended into 150/244, covering much of that square to a depth of 4-5 cm. This lens was assigned an environmental number <V1903> and sampled in 150/243, but because it was modern or at least still mixed (we found two pieces of plastic within it), it was not given a separate context number. Two local coins (a square hole in the centre of each) were found in this ashy lens and assigned 'Small Find' numbers 1 and 2, respectively. The (E901) deposit otherwise contained

infrequent gastropods and cyclophorids were recovered, but little else either at the trench side or at the sieves (where we were sieving one in every three buckets through 2 mm mesh). A partial smooth and likely introduced river cobble was removed and bagged trench-side from 150/243.

Figure 4: Excavating Trench 2, Hang Thung Binh 1 (Emilie Green and Nguyen Truong Dong) (photo: R. Rabett).

Contact with the underlying context (E902) was relatively clear across both squares. This context, a silty clay matrix, contained infrequent angular to sub-angular limestone inclusions and was moderately compact. It also contained infrequent shells (cyclophorid and riverine gastropods). A piece of glazed wear was excavated from 150/243, but the most significant find recovered in what was quite a sterile context (also sieved 1 in 3 buckets), was a polished shouldered axe from 150/243 (Small Find 3), which was photographed *in situ*, planned and levelled before digging resumed. In 150/244 digging was halted at the apparent contact with a browner, drier and more shell-rich layer. Digging continued in 150/243 on the assumption that we should arrive at the same deposit, instead (E902) persisted, and small (*c*. 5 x 5 cm) voids appeared. These might have been related to rocks (which were appearing the trench), but given what would be found later, it is also possible that these could have been voids created during backfilling (in antiquity). A large complete cowrie shell was recovered at this stage of excavations in 150/243. As we began the second 10 cm spit of (E902) in 150/243 the frequency of bone and shell increased moderately, leading us to think that we might be coming down onto the same contact revealed in 150/244. By this point all buckets were being sieved from 150/243 (E902) spit 2; however, the frequency of finds dropped off again. Given the increasingly complexity of the trench and the intrusion of rocks, which were by this point reducing the excavation area appreciably, we decided to open the adjacent squares 151/243 and 151/244. Work in these squares progressed quickly but methodically. Of note was a small

area of reddened sediment in the immediate subsurface of 151/243 in the SE corner. This was excavated and sampled as (E904). A human molar would later be recovered from an unexcavated extension of this context just outside the trench (Small Find 8).

Contact with (E903) was made in 151/244 and marked by a return to moderate frequencies of bone and shell. By the end of the day (09.09.17) this contact had been largely exposed across all four squares of the trench. As digging progressed in 151/244 a darker deposit, with modest frequencies of shell, bone and ceramic fragments, began to emerge (E905). This would ultimately cover an area of *c*. 30 x 30 x 10 cm. Contact was made with a similar but not identical deposit in 150/244 at this depth (E906). All buckets were sieved from both of these new contexts as we dug through them. In section it became apparent that one or both of these contexts were probably pockets, possibly pits dug into earlier deposits, as 15th century ceramic sherds were recovered from (E906), which were otherwise out of stratigraphic sequence from the cultural material being excavated – by this level within (E903) and notably in the southern half of 151/244 being post-Neolithic coarse ware.

Excavation of (E903) spit 2 in both 150/243 and 151/243 resulted in an increasing frequency of often quite large (*c*. 5 x 4 cm) coarse-ware ceramic sherds; small sherds were also coming out at the sieves from this spit. The fabric of these sherds is black, with a red 'slip' or other process of red colouration on the outer surface. Infrequent but quite large marine shells/shell fragments + the smaller bivalves coming out at the sieves. With no immediate change in sediment character, we continued to excavate (E903) in spits. Spit 4 proved to be significant for finds in both 150/243 and 151/243. Moderate amounts of bone starting to emerge, including a large (mostly complete) phalange in 151/243, which was later confirmed to be a human big toe first phalange, a large ceramic sherd (Small Find 5) and in almost direct association with this, a second smaller shouldered axe (Small Find 6) also from 151/243 (E903) spit 4, as too was a heavily worn human mandibular molar (Small Find 7) and a second smaller human phalange (Small Find 9). The former of these was located 30 mm below and in in very close spatial proximity a sample of charcoal <V1958>. Levels were established on each find and all were planned. Although they had been recovered infrequently from higher spits in this context, small (*c*. 5 mm) perforated shell discs were recovered at the sieves and the trench-side from this context and spit in both squares (though particularly 151/243).

These finds were followed by (and in all likelihood were related to) a much larger concentration (at least 9 fragments in an area: 0.6 x 0.6 m) of narrow-walled coarse ware sherds uncovered in close association and extending into the southern wall of the trench (north-facing section), partly in 151/243, mostly in 150/243 (figure 5). It is certainly plausible that most of these come from a single fragmented vessel, though confirmation of this will only be possible through conservation and reconstruction. These sherds were cleaned *in situ*, photographed and individually planned, before being lifted (with sterile gloves) and conserved in acid-free tissue for transport. Together with these sherds was a large (c. 20 cm long) fragment of mussel shell. Two fragments of bone (one apparently burnt, the other, another phalange) together with several more perforated discs were also lifted. Further fragments of ceramic were visible in the section and beneath those removed. (E903) spit 4 yielded a further eight ceramic fragments from the same immediate area as the principal concentration (some sherds – notably SF10.1 and 10.2 – have been left in-section), as well as more perforated shell discs, though no additional human remains. The presence of the Small Find 10 assemblage of pot sherds was taken as

the demarcation depth for (E903) and a new context (E907) was allocated to the deposits beneath it, even though these were ostensibly similar in a sedimentological sense.

Figure 5: concentration of coarse-ware sherds and isolated human remains (Small Find 10 assemblage) excavated in a 0.6 x 0.6 m area adjacent to the north-facing section of Trench 2, squares 150/243 and 151/243, context (E903) spit 4 (photo: R. Rabett).

Excavation of (E907) brought further frequent, but mostly small (1-5 cm), sherds of coarse-ware, which were bagged at the trench-side and at the sieves (through which all buckets were now passing). Bone and shell fragments, though present also, were being still conspicuously infrequent. The first confirmed Da But pottery appeared towards the base (10 cm) of the first spit of (E907) in square 151/243, and a large sherd recovered from within spit 2 of this context in 150/243 (SF11). This sherd was handled with sterile gloves, placed in acid-free tissue and boxed for potential residue analysis. Another human molar was recovered (also handled with sterile gloves) from sediment being sieved from 150/243 (E907) spit 2 (Small Find 12). This is likely to be a good candidate for aDNA analysis. Significant amounts of corded coarse ware continued to be recovered from spits 2 and 3 of this context. Towards the base of (E907) spit 3 the character of the deposit began to change: firstly, in eastern half of 151/243, contact with what a shell-rich context (E908) was chased back across this square and 150/243 over a slope that extends down towards the chamber interior. (E908) was ultimately excavated in two spits (1 and 2); the top of (E908) spit 3 essentially formed the base of excavation of this season for this context. While rare, small pottery fragments were recovered at the sieves during initial excavation of (E908), the remainder of the deposit that was excavated appeared to be devoid of ceramic. (E907) was completed in four spits. It was excavated until contact with (E908) in the east of the trench and a noticeable contextual change in the remainder of the trench, comprising a paler deposit, with a high content of degrading limestone. This deposit was excavated as (E909), onto the contact with (E908), which gradually appeared westward in the trench. A

small remainder of (E909) was left in the base of the trench, overlying the contact with E908 as a means to preserve the top of (E908) for subsequent excavation.

3.2 Excavation in Trench 1

Trench 1 was re-opened towards the end of the season in one square (151/251) and (in line with project convention) a new context was assigned for this season. Thus, from a sedimentological perspective (E800) = (C804) spit 5. All material was sieved. The frequency of cultural material was low, but did include several potentially knapped flakes, as well as infrequent riverine shells, land snail shells and bone fragments. Charcoal was found very infrequently, though one piece was surveyed within the trench <V1806> towards the base of (E800) spit 2. A change in deposit character at around this depth to one containing a somewhat elevated frequency of crushed and fragmented shells and angular to sub-angular limestone inclusions (5-10 cm range) signalled a contextual change. (E801) also contained a low but persistent occurrence of bone fragments (including intermediate-large mammal rib fragments); the surface of several pieces was noticeably degraded, comparable to Stage 3 or 4 under the Behrensmeyer schema (Behrensmeyer 1978: 151), where weathering has caused the cortical bone to become coarsely fibrous and rough in texture. Given the antiquity of the overlying shell midden, this increased weathering of the bone surface could be consistent with the effects of late Last Glacial Maximum aridity.

Digging in Trench 1 was halted in context (E801) spit 2, and 40 cm below our previous base of excavation, when rocks (likely roof-fall) extended over most of the trench. Finds by this point were infrequent, though sieved charcoal was recovered from the first spit of this context. In all likelihood, the base of occupation (or at least the phase we had been recording) had been reached.

3.3 Sampling for magnetic susceptibility

The composition of sediment minerology is largely determined by the climate in which it is formed and deposited. Therefore, magnetic readings can provide numerical data which upon further analysis can determine climatic variations of the past. With the dating of the sediment of Trench 1 to 17,500 years BP, paleomonsoons which have occurred within this time will be identified and dated. The re-opening and extension of the north east section of the trench this season has enabled sediment collection from a greater depth, extending the investigation deeper into the Pleistocene. With increased concern for the potential effects of continued global warming and rising sea levels, the study of periods of inundations in this area have the potential to better inform modern responses to our changing climate.

Between the 12th and 13th of September 2017, Bartington MS2 Magnetic Susceptibility System probes D (MS2D) and F (MS2F) were used to collect in field magnetic susceptibility readings of the sediment within Thung Binh 1. Specifically, the MS2D and MS2F probes were used to record the magnetic susceptibility of Trench 1, excavated in the March-April 2017 field season by the SUNDASIA team as well as the trench opened by the Institute of Archaeology in 2012 (figure 6). In undertaking probe measurements, the same section of sediment was measured 3 times to eliminate the possibility of error. However, inaccuracies in measurements were evident from the outset with the failure to obtain consistent results. With magnetic variations of 347 to -124 in the same spot of sediment, the method of sample collection was reassessed. It is believed that

humidity levels of 97% and temperatures of 37 degrees may have contributed to these errors as well as potential mechanical errors out of the team's control.

Figure 6: MS2B sample readings being collected in Trench 1, Thung Binh 1 (Dr Fiona Coward and Meghan McAllister) (photo: R. Rabett).

To ensure data was obtained, an alternative method was employed, involving collection of environmental samples of 10 grams each every 5 cm down a vertical transect of the south facing walls of Trench 1 and the Institute of Archaeology trench. This was undertaken between the 13th and 14th September (figure 7). These samples will be returned to the United Kingdom and tested using the MS2B system within a controlled laboratory environment of Bournemouth University. This method proved successful in producing consistent readings from sediment sampled taken from Hang Trong. The data from Hang Trong will potentially be used to provide a site-to-site comparison of readings to determine any regional variations of dates between the two caves.

Figure 7: Meghan McAllister and Rachael Holmes extracting a sample column from the Institute of Archaeology trench in Thung Binh 1 (photo: R. Rabett).

3.4 Material culture – lithics

The 2017 excavations at Thung Binh 1 yielded a significant collection of lithic material (n = 75). The assemblage is composed primarily of informal flakes and flake fragments with technological markers (i.e. bulb of percussion, recurrent dorsal scars, use-wear, retouch) and several small cores, but is highlighted by one pebble core tool and two edge-ground shouldered axes. Here, I will discuss major elements of the assemblage and possible avenues of research for each.

The lithic assemblage from Thung Binh 1 is composed primarily of highly variable and informal flakes. Characterizations of other assemblages from Tràng An have demonstrated that attribute analysis is an effective means of characterizing both temporal variability and site-specific spatial variability in such material (Phan 2014; Rabett *et al*. 2017; Utting 2017). Therefore, an attribute analysis of the lithics from Thung Binh 1 might shed light not only on technological variability over time, but on post-depositional site formation processes and spatial organization by the prehistoric inhabitants of Thung Binh 1. The pebble core tool is highly significant, as it broadly resembles a 'sumatralith', widely recognized as the 'fossile directeur' of the Hoabinhian (e.g. Callenfels & Evans 1928; White & Gorman 2004). The core is not knapped around its entire circumference, and therefore does not fulfill all requirements for being a 'sumatralith'. However, it is a highly significant find because it represents the strongest lithic evidence of the Hoabinhian at Tràng An to date.

The two edge-ground shouldered axes are important because they might lend to a greater understanding of the Neolithic in northern Vietnam. Here, three studies will be proposed in order to establish a foundation for future research into Neolithic stone tool technology at Tràng An. The first study involves raw material sourcing. By understanding the source of the raw material for these specimens, we might gain insight towards networks

of exchange within and outside of Tràng An and northern Vietnam. A second study involves use-wear analysis. One of the shouldered axes bears macroscopic edge damage, which could stem from use-wear. By investigating this damage further, we might be able to place the axe within a technological context. A third and final study involves geometric morphometrics. Shouldered axes have 14 discrete, independent morphological points. By characterizing variability in shouldered axe morphology using this data, it might be possible to identify variability in shouldered axes via geometric morphometrics. This information could potentially be applied in order to characterize spatial and temporal variability in different time periods, and among different regions.

The Hang Thung Binh 1 lithic assemblage breakdown by dataclass across the two excavated trenches this season was overall, as follows: 22 complete flakes, 5 cores, 30 flake fragments, 5 retouched flakes, 11 pieces of shatter, 2 shouldered axes; breakdown by trench was, as follows:

- **Trench 1**: 12 complete flakes, 2 cores, 18 flake fragments, 2 retouched flakes, 11 pieces of shatter;
- **Trench 2**: 10 complete flakes, 3 cores, 12 flake fragments, 3 retouched flakes, 2 shouldered axes

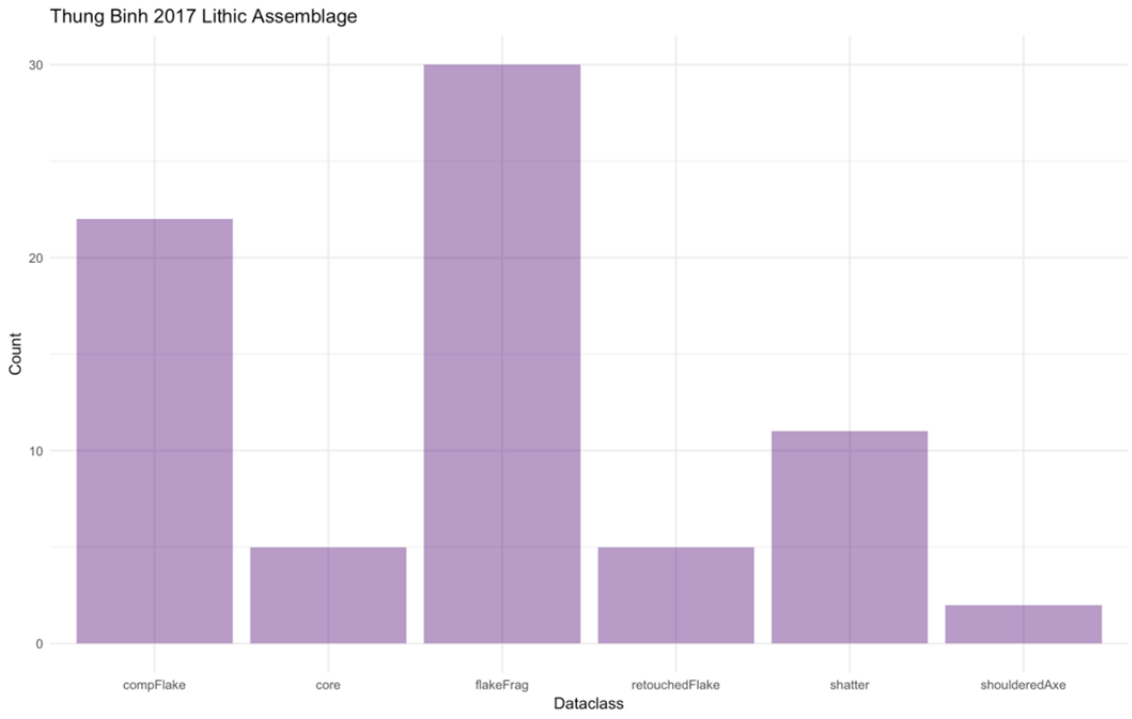

Figure 8: Overall breakdown of lithics from excavation in Trenches 1 and 2 by dataclass at Hang Thung Binh 1 during the September 2017 season (data: B. Utting).

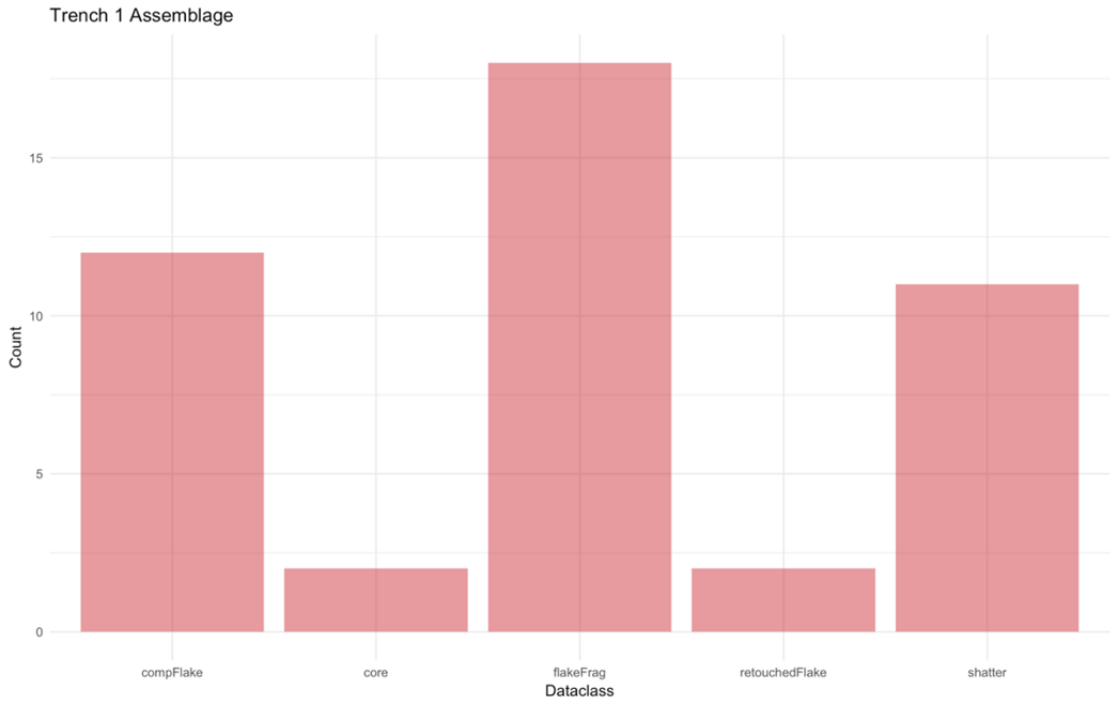

Figure 9: Breakdown of lithics by dataclass from Trench 1, Hang Thung Binh 1 (data: B. Utting).

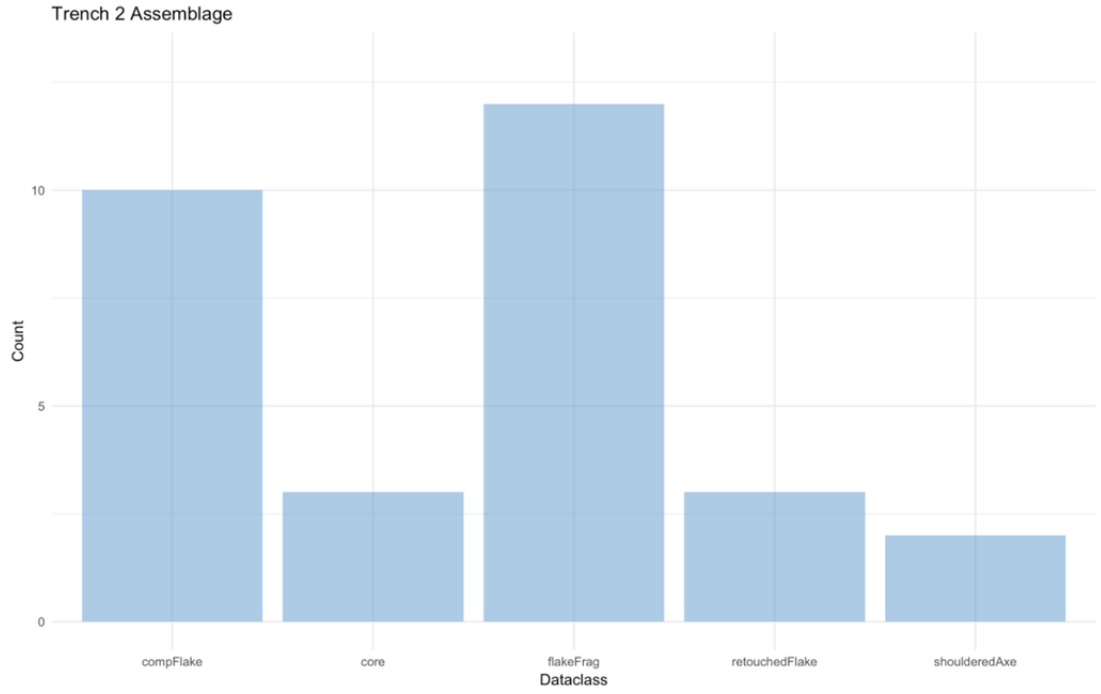

Figure 10: Breakdown of lithics by dataclass from Trench 2, Hang Thung Binh 1 (data: B. Utting).

4. MODERN LAND SNAIL (*CYCLOPHORUS* SP.) SURVEY

During the September season samples of modern live and dead land snails (predominantly *Cyclophorus* sp.) were collected from all areas of the Tràng An core zone. The approach taken by the survey was to systematically obtain specimens (approximately two dozen where possible) from each of the eight cartographic grid squares that cover the core zone area. This had the objective of providing a comprehensive spread of baseline data from which to assess

in the laboratory the range of isotopic variability in land snail shells from different locations across this landscape. These data will help ensure that the calibration curve that is to be created to date archaeological samples of cyclophorid shell can be (if necessary) locally adjusted to account for subtle differences in probable carbon uptake.

Fieldwork during the summer monsoon provided an excellent opportunity to collect specimens when they are at their most active (particularly during and immediately after spells of rain), rather than while they are estivating and harder to locate. Field collection was timed accordingly to take advantage of these activity periods. Live specimens were collected from a number of locations (e.g. Buffalo Eco Garden, Thôn Bình Khê, Xã Ninh Nhất, Ninh Nhất, and Ninh Bình) where pools of water or moist conditions persisted in and around limestone outcrops (figure 11). *Cyclophorus* sp. shells were found in between sediment and dead leaves at the base of the limestone cliffs (e.g. Chùa Bích Động, Danh thắng Tam Cốc–Bích Động, Ninh Hải and Hoa Lư).

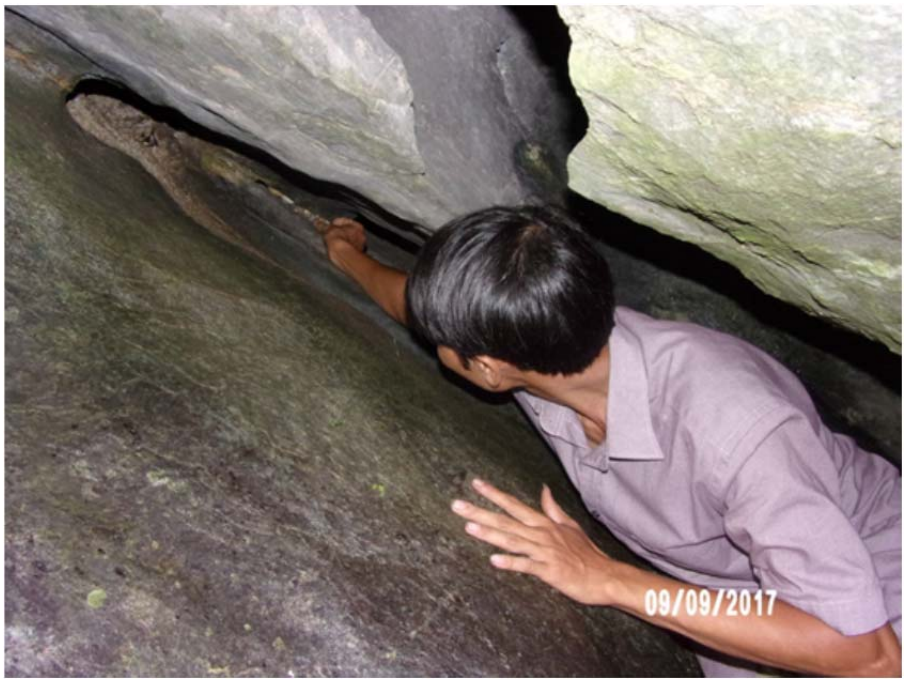

Figure 11: Working with a local guide to find snails in between the limestone cracks near Buffalo Eco Garden, Ninh Binh (photo: I. Bachtsevanidou Strantzali).

A total of 64 samples were obtained (these included living and dead snails, as well as examples of foliage being consumed, a small (*c*. 10g) sediment sample from the immediate vicinity of the collection site, and additional associated materials (such as limestone). All samples and sample assemblages were catalogued using the 'enviro number' and unique identifier system enabling them to be entered into the Project's GIS database.

5. POLLEN TRAP, EXPLORATIVE CORING CAMPAIGN

This section of the report details the initial stages of the ongoing programme of reconstructing the vegetation history of Tràng An. This work was conducted from 9-21 September 2017. The dual sub-objectives of this season's work are first defined. Outcomes of the work in relation to these objectives are then presented. The dual sub-objectives of the September 2017 field season's botanical and palaeo-vegetational programme were:

- To begin deployment of a network of pollen traps aimed at catching the 'pollen rain' from modern vegetation surrounding sites from which subfossil pollen assemblages will later be extracted;

- To auger potential pollen-bearing deposits within the broader landscape, and assess their likely degrees of pollen preservation, in order to prospect for sites of future pollen cores.

Both of these dual sub-objectives were driven by the aim of improving our understanding of the history of vegetation at Tràng An.

5.1 *Pollen traps*

Placement of pollen traps was guided by the aim of clarifying and quantifying taphonomic relationships between modern vegetation and its pollen rain that falls onto, and is incorporated into, sedimentary deposits. Such sedimentary deposits that may potentially bear preserved pollen assemblages come from caves and rockshelters that are foci of present and past archaeological excavations, as well as from depositional points within the surrounding open landscape. A total of 16 pollen traps were deployed across various sites during the September 2017 field season (Table 2). These comprise 12 traps in different positions within caves and rockshelters, as well as four traps at open-landscape sites near to previous or potential future boreholes/cores. Appendix 1 comprises a botanical taxon list of preliminary field determinations of plants noted around sites of deployed pollen traps.

Site	Trap #	Position
Hang Ang Noi	R2200	Back of chamber, beneath bat roost
	R2201	Front-centre of cave mouth, just inside drip-line, affixed to fence post
Hang Moi	R2202	Back of chamber, next to TAP 2011 & Vietnamese Team trenches
	R2203	Corner of cave mouth, inside drip-line, adjacent to trench dug into ashy midden
Hang Hanh	R2204	Hung from overhang ~2.5m above rockshelter floor
Thung Binh	R2205	Back of main chamber
	R2206	Upper (small) chamber, beyond northern wall of trench
	R2207	South corner of cave mouth, in front of main trench, affixed to fence post
Mai da Ong Hay	R2208	Hanging within a vertical crevice above flooded cave floor
	R2209	Affixed to young *Ficus* tree in open landscape ~ 50m in front of cave (near TAK2)
Mai da Vang	R2210	Hanging from rock ledge ~ 2.5m above rockshelter floor
	R2211	Affixed to leg of large metal sign at bridge over river, in open landscape ~250m in front of Rockshelter (near TAK1)
Den Thai Vi	R2212	Affixed to limestone outcrop in paddy south of Den Thai Vi (not visible from road) (near TAK9)
Hang Boi	R2213	Back of chamber, affixed to fence enclosing open trench
	R2214	Front-centre of cave mouth, just inside drip-line, affixed to fence post
Thung Chua	R2215	Affixed to *Mallotus* tree on forested floor of doline

Table 2: Sites, trap numbers and positions within sites of the 16 pollen traps deployed during September 2017.

5.2 *Augering*

Exploratory augering for potential pollen-bearing sedimentary sequences was conducted at two sites during the September 2017 field season. Within the cultivated alluvial landscape in front of (east from) Thung Binh, sediments were augered at three points (TB1a, TB1b and TB1c) along an east-west transect perpendicular to the southward flowing stream. Figure 1 shows the relative locations of the three augering sites in relation to Thung Binh. Descriptions of the sedimentary units encountered are presented in Tables 3, 4 and 5. Graphical representation of the three sediment columns is presented in Figure 12.

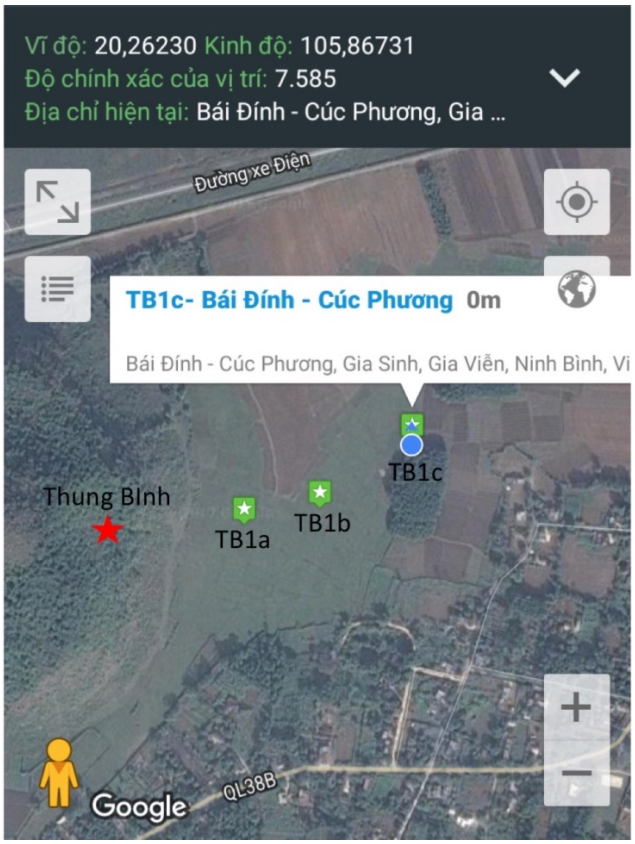

Figure 12: Relative locations of TB1a, TBlb and TBlc augering in relation to Thung Binh 1.

TB1a		
Depth (cm)	**Description**	**Munsell**
0-15	Brown clay, with few Manganese gravel inclusions ~2-3mm	10YR/4/3 "dull yellowish brown"
15-36	Brown clay (stickier than above), moderate amount of Manganese gravel	10YR/4/3 "dull yellowish brown"
36-52	Gray clay, high Manganese gravel (2-3mm) content; single limestone fragment 10-12mm @67cm depth	10YR/4/1 "brownish gray"
52-90	Brownish gray clay, high Manganese and Iron gravel (1-2mm)	10YR/5/1 "brownish gray"
90-112	Gray clay with moderate light gray mottling; small (1-2mm) Mn & Fe nodule	10YR/5/1 "brownish gray"

112-135	Gray clay, gradually getting lighter with depth, iron mottling (redox); maximum depth reached with hand mechanical power	10YR/5/1 "brownish gray"

Table 3: Lithological descriptions of sedimentary units encountered at auger site TB1a.

TB1b		
Depth (cm)	**Description**	**Munsell**
0-5	Rootlets of grass	
5-10	Organic sandy mud with Mn & Fe nodules (2-3mm)	
10-33	Brown clay with rounded Mn nodules (3-5mm)	10YR/4/4 "brown"
33-45	Brown clay, more oxidised than above, single rounded limestone inclusion (2-4mm)	2.5Y/4/1 "yellowish gray"
45-124	Brown clay, less Mn gravel of smaller clast size (1-2mm)	2.5Y/4/1 "yellowish gray"
124-135	Brown sandy clay with increased Mn & Fe inclusions	10YR/5/4 "dull yellowish brown"
135-145	Lost sediment	
145-160	Yellowish brown clay, gradually changing back to yellowish gray, with Mn inclusions (2-3mm)	10YR/5/4 "dull yellowish brown"
160-165	Dull yellowish brown clay with angular gravel	10YR/5/4 "dull yellowish brown"
165-175	Lost sediment (but probably heavy clay)	
175-180	Yellowish gray clay with blue mottling	10YR/5/4 "dull yellowish brown"
180-190	Lost sediment (but probably silty clay)	
190-195	Blue silty clay with small (1-2mm), angular limestone colluvium	
195-205	Lost sediment	
205-210	Sandy angular gravel; small root inclusion	10YR/5/4 "dull yellowish brown"

Table 4**:** Lithological descriptions of sedimentary units encountered at auger site TB1b.

TB1c		
Depth	**Description**	**Munsell**
0-15	Brown organic clay with few rounded gravel inclusions (0.5-5mm); rootlets down to 7cm depth	2.5Y/4/2 "dark grayish"
15-38	Brown clay with moderate Mn & Fe gravel inclusions; lower water content	2.5Y/3/3 "dark olive brown"
38-60	Brown clayey gravel (1-2mm) with iron mottling; rounded limestone fragment, few rootlets	2.5Y/4/3 "olive brown"
60-85	Brown clayey gravel (2-5mm); redox / iron mottling	2.5Y/4/4 "olive brown"
85-90	Gray clay, heavily redoxed	2.5Y/5/2 "dark grayish"
90-105	Gray clay, redoxed	2.5Y/4/1 "yellowish gray"

105-135	Gray clay, with few small gravel inclusions	2.5Y/3/2 "brownish black"
135-150	Lost sediment	
150-155	Gray clay, with few small gravel inclusions	2.5Y/3/2 "brownish black"
155-165	Brown mottled clay; at very bottom, dark green sandy clay (marine?)	2.5Y/3/3 "dark olive brown", mottled with 2.5Y/4/4 "olive brown"
165-180	Dark green sandy clay; couldn't go deeper by hand	10GY/4/1 "dark greenish gray"

Table 5**:** Lithological descriptions of sedimentary units encountered at auger site TB1c.

These sequences are interpreted to represent colluvial (TB1a), floodplain and channel deposits (TB1b and TB1c) of a low-energy meandering stream east of the foot of the isolated limestone tower that houses the cave of Thung Binh 1. Based upon the nature of the notional mangrove and marine deposits at the base of TB1c, these deposits likely date to the late Holocene, post-4000 BP when the sea regressed following the Dong Da transgression (*c*. 7000-4000 BP). Whilst evidence of redox does not bode well for pollen preservation, the more reduced sediments from ~1m depth and below, which also include the notional mangrove and marine sediments at the base, may contain palynological signatures of littoral, mangrove and estuarine vegetation that likely occurred in the area during the hundreds of years to millennia (??) as the sea regressed following the Dong Da transgression. Indeed, TB1c appears to be located near to the site of VIGMR's TAK5 borehole, which contains moderately diverse pollen assemblages, though in low concentrations (Pham & Nguyen, unpublished data from 2012).

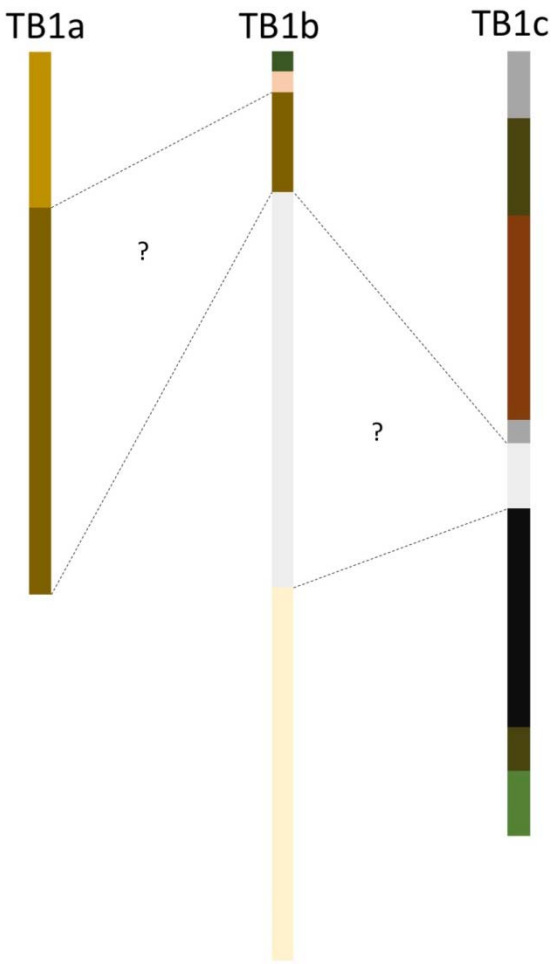

Figure 13: Graphical representation of auger core lithologies, with tentative stratigraphic correlations represented by dotted lines (illustration: S. O'Donnell).

Additionally, the sediments that comprise the floor of the doline called Thung Chua, located approximately 2 km SSE from Thung Binh 1, were augered. Descriptions of the sedimentary units encountered are presented in Table 6.

Thung Chua	
Depth (cm)	**Description**
0-11	Brown organic silty clay
11-43	Light yellowish-brown clayey silt with dark brown mottling; dry, friable angular limestone inclusions
43-53	Grayish-brown organic clay
53-120	Light yellowish-brown silty clay with oxidised Fe mottling; crumbly limestone inclusions

Table 6: Lithological descriptions of sedimentary units encountered during augering of Thung Chua.

Based upon the sediments encountered, the portion of the Thung Chua doline that was augered appears to contain deposits of oxidised colluvium from the weathered limestone walls that enclose the circular depression, combined with organic matter from the vegetation growing atop the valley floor. The degree of oxidation of the sediments suggests that the

valley floor has remained well above the local water table. It is unlikely that such conditions will have promoted the preservation of sedimentary pollen assemblages.

5.3 *Taxonomic list of plant*s

Taxon	Family *sensu* APG IV (2016)	Location
Ruellia tuberosa L.	Acanthaceae	Hang Hạnh, Tràng An, Bái Đính, Vàng rock shelter
Mangifera indica L.	Anacardiacae	
Achyranthes aspera L.	Amaranthaceae	
Amaranthus viridis L.	Amaranthaceae	Hang Hạnh, Bái Đính
Celosia argentea L.	Amaranthaceae	
Dracontomelon duperreanum Pierre	Anacardiaceae	Hang Mòi, Tràng An, Bái Đính
Annona muricata L.	Annonaceae	Bích Động
Annona squamosa L.	Annonaceae	Hang Hạnh, Vang rock shelter, Langur Island, Tran temple, Boi cave
Artabotrys fragans Ast	Annonaceae	Tràng An
Desmos chinensis Lour.	Annonaceae	Langur Island
Desmos cochinchinensis (Lour.) S.C.Chen	Annonaceae	Langur Island
Alstonia scholaris (L.) R.Br.	Apocynaceae	
Plumeria rubra L.	Apocynaceae	Bái Đính, Thái Vi temple
Alocasia indica Schott	Araceae	Áng Nồi, Thung BÌnh, Hang Bói, Tràng An, Langur Island
Alocasia macrorrhizos (L.) G.Don.	Araceae	Langur Island
Amorphophallus konjac K.Koch	Araceae	Thung Bình
Pistia stratiotes L.	Araceae	Bich dong, Thai Vi, Hanh cave, Ong Hay cave
Schefflera pes-avis R.Vig.	Araliaceae	Cúc Phương
Arenga pinnata Merr.	Arecaceae	Hang Mòi, Thung Ui, Tràng An
Caryota monostachya Becc.	Arecaceae	Langur Island
Caryota sympetala Gagnep.	Arecaceae	Hang Mòi, Hang Bói, Tràng An
Dracaena cochinchinensis (Lour.) S.C.Chen	Asparagaceae	Boi cave, Trang An, Moi cave, Thung Ui, Bich động, Thái Vi
Asplenium nidus L.	Aspleniaceae	Tràng An, Đền Trần, Hang Mòi
Ageratum conyzoides L.	Asteraceae	Widespread
Bidens pilosa L.	Asteraceae	Widespread
Impatiens alborosea Tardieu	Balsaminaceae	Tràng An, Bích Động
Impatiens bonii Hook.f.	Balsaminaceae	Hang Mòi, hang Bói, Tràng An
Begonia sp.	Begoniaceae	Langur Island
Oroxylum indicum (L.) Benth. ex Kurz	Bignoniaceae	Tràng An, Thung Ui

Lonicera spp.	Caprifoliaceae	Hang Hạnh
Combretum indicum (L.) DeFilipps	Combretaceae	Bích Động
Terminalia catappa L.	Combretaceae	Trang An, Thai Vi, Bích dong
Commelina paludosa Blume	Commelinaceae	hang Hạnh, Thung Bình, Bích động, Thái Vi
Argyreia acuta Lour.	Convolvulaceae	Langur Island
Alangium kurzii Craib	Cornaceae	Thung ui, Tràng An, Ong Hay, Vang rock shelter
Bryophyllum pinnatum Asch. & Schweinf.	Crassulaceae	Langur Island
Luffa cylindrica M.Roem.	Cucurbitaceae	Langur Island
Momordica cochinchinensis (Lour.) Spreng.	Cucurbitaceae	Tràng An, small island
Dillenia sp.	Dilleniaceae	Langur Island
Dioscorea spp.	Dioscoreaceae	Boi cave, Cúc Phương, Langur Island
Euphorbia hirta L.	Euphorbiaceae	Langur Island
Euphorbia sp.	Euphorbiaceae	Langur Island
Mallotus spp.	Euphorbiaceae	Hang Hạnh, Thung Bình, Langur Island
Ricinus communis L.	Euphorbiaceae	Bái đính, Hang Hạnh
Securinega virosa (Willd.) Baill.	Euphorbiaceae	Langur Island, bích động, Cúc Phương
Chirita hamosa R.Br	Gesneriaceae	Moi cave, Langur Island
Callicarpa sp.	Lamiaceae	Langur Island
Clerodendrum chinense (Osbeck) Mabb.	Lamiaceae	
Clerodendrum japonicum (Thunb.) Sweet	Lamiaceae	Hang Hạnh, Bái Đính, Tràng An
Gmelina sp.	Lamiaceae	Langur Island
Ocimum tenuiflorum L.	Lamiaceae	Hang Hạnh, Bái Đính,
Ocimum gratissimum L.	Lamiaceae	Thung Bình
Barringtonia acutangula (L.) Gaertn.	Lecythidaceae	Bái Đính, Tràng An
Mimosa invisa Mart. ex Colla	Leguminosae	
Mimosa pudica L.	Leguminosae	
Papilionoidea sp.	Leguminosae	
Saraca dives Pierre	Leguminosae	Cúc Phương, Boi cave
Loranthaceae sp.	Loranthaceae	Hang Hạnh
Lygodium spp.	Lygodiaceae	Langur Island
Abelmoschus mutabilis (L.) Wall ex Hassk.	Malvaceae	Tràng An, Hang Hạnh, Thung Ui, Thung Bình, Vang Rock shelter
Bombax ceiba L.	Malvaceae	Tràng An, Bích Động
Grewia paniculata Roxb.	Malvaceae	Thung Ui
Grewia spp.	Malvaceae	
Malvaceae sp.	Malvaceae	
Sida acuta R.Br.	Malvaceae	
Urena lobata L.	Malvaceae	Bích Động
Melia azedarach L.	Meliaceae	Tràng An, Thái Vi, Vàng Rock shelter, Hang Hạnh, Thung Bình
Cissampelos pareira L.	Menispermaceae	

Stephania rotunda Lour.	Menispermaceae	
Nymphoides indica (L.) Kuntze	Meryanthaceae	Hang hạnh, Tràng An
Artocapus heterophyllus Lam.	Moraceae	Tràng An
Broussonetia papyrifera (L.) Vent.	Moraceae	Langur Island
Ficus bengalensis L.	Moraceae	Tràng An, Bái Đính
Ficus benjamina L.	Moraceae	Tràng An, Hang Mòi
Ficus hispida L.f.	Moraceae	
Ficus pumila L.	Moraceae	Bích Động
Ficus racemosa L.	Moraceae	Hanh cave, Ong Hay cave, Langur Island, Trang An
Ficus religiosa L.	Moraceae	Bái Đính
Ficus stricta Miq.	Moraceae	Tràng An, Hang Mòi
Streblus asper Lour.	Moraceae	Langur Island, bích động, Cúc Phương, Thung Bình
Tremotis cordata Raf.	Moraceae	Hang Mòi
Musa acuminata Colla	Musaceae	Boi cave, Hanh cave, Langur Island
Cleistocalyx operculatus (Roxb.) Merr. & L.M. Perry	Myrtaceae	Tràng An, Bích động
Eucalyptus sp.	Myrtaceae	Tràng An
Psidium guajava L.	Myrtaceae	
Nelumbo nucifera Gaertn.	Nelumbonaceae	Tràng An
Nymphaea ruba Roxb. ex Solisb.	Nymphaeaceae	Tràng An
Ludwigia octovalvis (Jacq.) P.H.Raven	Onagraceae	Thung Bình, bích động
Averrhoa carambola L.	Oxalidaceae	Hang Hạnh, Trần Temple
Oxalis corymbosa DC.	Oxalidaceae	
Pandanus odorifer (Forssk.) Kuntze	Pandanaceae	Thung Bình, Ong Hay cave,
Passiflora foetida L.	Passifloraceae	Small Island Tràng An, Bích động
Phyllanthus reticulatus Poir.	Phyllanthaceae	Tràng An, Thung Ui, Thung Bình, Vang Rock shelter, Langur Island
Piper lolot C.DC.	Piperaceae	Langur Island
Bambusa spp.	Poaceae	Langur Island
Oryza sativa L.	Poaceae	Thung Bình, Hang Hạnh
Eichhornia crassipes (Mart.) Solms	Pontederiaceae	Bich dong, Thai Vi, Hanh cave, Ong Hay cave
Portulaca oleracea L.	Portulacaceae	Langur Island
Naravelia zeylanica DC.	Ranunculaceae	Thung ui (hoa có mùi thơm)
Ziziphus mauritiana Lam.	Rhamnaceae	Tràng An, Hang Hạnh, Vang Rock shelter, Bái Đính
Rubus fruiticosus L.	Rosaceae	Hang Hạnh, Bái Đính, Tràng An, Langur Island
Rubus moluccanus L. var. *alcaefolius* (Poir) Kuntze	Rosaceae	Hang Hạnh, Thung Ui,
Mussaenda glabra Vahl	Rubiaceae	Langur Island
Neolamarckia cadamba (Roxb.) Bosser	Rubiaceae	Langur Island, Tràng An

Neonauclea sessilifolia Merr.	Rubiaceae	Tràng An, Bích Động, Thung Ui, Cúc Phương
Paedria foetida L.	Rubiaceae	Small Island Tràng An, Bích động
Randia tomentosa Wight. & Arn.	Rubiaceae	Thung Bình
Clausena lansium Skeels	Rutaceae	Langur Island
Zanthoxylum nitidum DC.	Rutaceae	Langur Island
Salvinia cucullata Bory	Salviniaceae	Áng Nồi, Bích động
Dimocarpus longan Lour.	Sapindaceae	Langur Island
Pouteria lucuma Kuntze	Sapotaceae	Langur Island
Solanum sp.	Solanaceae	Widespread
Symplocos cochinchinensis S.Moore	Symplocaceae	Langur Island
Typha spp.	Typhaceae	Tràng An, Bich Dong
Laportea interrupta (L.) Chew	Urticaceae	Langur Island
Lantana camara L.	Verbenaceae	Widespread
Cissus modecoides Planch.	Vitaceae	Langur Island
Alpinia malaccensis (Burm.f.) Roscoe	Zingiberaceae	Áng Nồi, Tràng An, Thung Ui
Alpinia tonkinensis Gagnep.	Zingeberaceae	Áng Nồi, Thung BÌnh, Hang Bói, Tràng An, Langur Island

Table 7: Aggregate botanical taxon list across all sites visited during the September 2017 field season. Field determinations are preliminary. Taxon list does not comprise a complete species list for Tràng An.

6. CONSERVATION PROGRAMME (TRAIL CAMERAS, SMALL VERTEBRATES & ISLAND SURVEY)

6.1 Trail cameras

Through the identification of animal bones recovered in the archaeological excavations, the SUNDASIA project is also building picture of larger vertebrate diversity in the Tràng An World Heritage property, dating from at least the period 30,000 years to 5000 years before present. While this record reflects largely the hunting behaviour of prehistoric people, and as such is an inherently incomplete sample (as indeed all such fossil records are), it is nonetheless establishing a broad long-term picture of animal communities within this area. These data are essential to the archaeological reconstruction of past behaviour and responses to environmental change (as well as potentially environmental impact of human behaviour), but it is equally important for the aims of the project that these trends and patterns are followed through and linked into modern conditions, rather than being left isolated from them. At present, we already know more about the prehistoric animal life in the karst area than we do the animal life that occurring here today. There have been, however, limited direct observations of larger mammals by project members. For example, a hog badger, *Arctonyx collaris* (a poorly-known mustelid classified as "Vulnerable" by the IUCN due to habitat loss and hunting pressure (Duckworth *et al*. 2016)), was seen near the Tran Temple in 2014, and the (at least periodic) presence of primates was reconfirmed by sightings of macaques (likely *Macaca mulatta*) in September 2017 within the core area of the property.

As well as consulting with local people about their knowledge of animals in the World Heritage area, the Project has initiated (in September 2017) a passive monitoring programme using trail cameras to begin to address this gap in our knowledge of the property – the initial focus is on medium to large terrestrial mammals (e.g. civets - Viverridae, deer – Cervidae, badgers - Mustelidae). This method has been shown to be a reliable and robust means of monitoring mammals in the forested tropics (e.g. Tobler et al., 2008). A series of motion-activated, static 24MP trail cameras using infrared flash are being set up within the property: first as a trial (figure 14), and then from November 2017 the Project will intensively sample 1 km grid squares (i.e. accumulate *c.* 500 'camera days' per square, using up to eight cameras per square) in the core area of the World Heritage, over the next year. The results from these campaigns will not only provide data for comparison with the prehistoric samples, but also provide basic, but invaluable insights into the current state of vertebrate biodiversity within the park.

Figure 14: Dr Christopher Stimpson (Queen's University Belfast) checking preliminary trail camera placements within the core zone (vicinity of the Tran Temple) (19th September 2017) (photo: R. Rabett).

6.2 Small vertebrate monitoring programme

Details of the archaeological investigation at Hang Ang Noi (20.275000 N, 105.916667 E) have appeared in a previous report (Rabett *et al.* n.d.). Our original work at this site further revealed an abundance of recent (i.e. non-archaeological) skeletal remains of small vertebrate taxa in surface deposits towards the back of the cave. These assemblages comprise of skeletal remains from naturally-occurring cave vertebrates (chiefly, bats - Chiroptera) along with the bones deposited by owls (likely fish owls: *Bubo* sp.) using the cave as a roosting site: the latter comprise the remains of ingested prey that is essentially skeletonised and then regurgitated by the owl and incorporated into the cave deposits. The study of cave-roosting species, like bats and owls, provides a ready and inexpensive means to characterise and even assess trends in the character of local small vertebrate communities.

Hang Ang Noi occupies a position within the core zone of the property that is comparatively close (*c.* 0.5 km) to an arterial route through Tràng An, making the record from here potentially sensitive to external disturbance and a good marker for the health of the local environment.

At the time of writing (September 2017) systematic collection of samples of this material by the SUNDASIA project (*see* figure 15) has been made on four occasions (commencing in September 2016). Identification of small vertebrate taxa is being undertaken at the Oxford University Museum of Natural History and Queen's University Belfast. Analysis is in its early stages; however, a preliminary examination has indicated that the assemblages include skeletal elements from fruit bats (*Rousettus*, *Cynopterus*), insectivorous bats (*Hipposideros*, *Taphozous*, *Scotophilus*) shrews (Soricidae), murid rodents (Muridae), tree shrew (*Tupaia belangeri*), voles (Microtinae), frogs (Anura) and birds (Aves) and thus, a range of small vertebrate taxa are represented. While the focus will be necessarily on cave-dwelling vertebrates and be biased by the hunting preferences of owls, this material will yield basic biodiversity data, where none exists currently, as taxonomic identifications are refined.

Figure 15: Dr Christopher Stimpson, Aaron Redmond and Dr Nguyen Truong Dong collecting guano and deadfall samples at Hang Ang Noi, Tràng An (September 2017) (photo: R. Rabett).

6.3 *Island Botanical Survey*

On the afternoon of 18th September and the morning of 19th September 2017, a team from SUNDASIA (led by Dr Shawn O'Donnell and Dr Nguyen Thi Mai Huong) surveyed the vegetation on the small limestone island approximately one kilometre northwest of the Tràng An Visitor Centre main wharf (figure 16). A significant element of the SUNDASIA project involves the reconstruction of past environments across this landscape and, as with the project's faunal analysis, connecting long-term patterns of vegetative change to present conditions forms an essential part of that work. This particular exercise not only expands upon the current state of knowledge regarding vegetation communities in Tràng An (*see* e.g.

Do Yen Ngoc 2012), it is linked to an initiative being explored by the Management Board with the Xuan Truong Enterprise and Vietnam Primate Conservation Programme, which in time may see the reintroduction of the critically endangered Delacour's Langur (*Trachypithecus delacouri*) to Tràng An.

Figure 16: An aerial view of the island whose vegetative cover is described in this report. The boat carrying the survey team is visible in the bottom right of frame. The island is located in the Tràng An core zone, close to the Visitor Centre (photo: T. Kahlert).

The island vegetation in this brief survey is described as limestone scrub. Soil is usually absent (most of the interior area), or composed of thin clays (e.g. within crevices between angular limestone boulders). There are several exposures of bare, sharp limestone, especially on the island's steeper slopes. The architecture of the vegetation can be described as simple, comprising a single open stratum. Across most of the island, this stratum comprises closely spaced shrubs and small trees rarely exceeding two to three metres in height, with scattered larger trees (usually *Ficus* spp., of the family Moraceae) on gentler slopes, growing within localised pockets of thin soil, or at the water's edge. Climbing vines (especially *Cissus modeccoides* Planch., *Paederia foetida* L. and a papilionoid legume) are present atop and bind adjacent shrubs and treelets. The most abundant plant family is Moraceae, which alone account for more than 30 per cent of the *c*. 70 preferred species of plant in the diet of the wild Delacour's Langur (Nadler & Brockman 2014). This family is represented predominantly by several species of fig (genus *Ficus*) and collectively, species of Moraceae cover over one third of the area of the island. The second most abundant family is likely to be Annonaceae. This covers *c*. 15-20 per cent of the island surface area. Several individual small trees of a species of *Alangium* (Cornaceae, previously Alangiaceae) were noted as prominent elements, as well as the heavily armed *Zanthoxylum nitidum* DC. (Rutaceae). Cultivated fruit trees such as jackfruit (*Artocarpus heterophyllus* Lam.), longan (*Dimocarpus longan* Lour.), banana (*Musa acuminata* Colla) and guava (*Psidium guajava* L.) are

growing at the water's edge, alongside several common agricultural weeds (e.g. *Bidens pilosa* L., *Ageratum conyzoides* L. and *Lantana camara* L.) and fast-growing taxa that are pioneers in forest gaps and edges (e.g. *Mallotus* spp., *Gmelina* sp. and *Mimosa invisa* Mart. ex Colla). Table 8 lists the taxa identified in the field. These identifications were made primarily from the water's edge, with only limited progress over the sharp limestone terrain and tangled vegetation of the interior.

Taxon	**Family *sensu* APG IV (2016)**
Annona muricata L.	Annonaceae
Desmos chinensis Lour.	Annonaceae
Desmos cochinchinensis Lour.	Annonaceae
Alocasia macrorrhizos (L.) G.Don	Araceae
Alocasia sp.	Araceae
Caryota monostachya Becc.	Arecaceae (Palmae)
Dracaena cochinchinensis (Lour.) S.C.Chen	Asparagaceae (Dracaenaceae)
Ageratum conyzoides L.	Asteraceae (Compositae)
Bidens pilosa L.	Asteraceae (Compositae)
Impatiens sp.	Balsaminaceae
Begonia sp.	Begoniaceae
Argyreia acuta Lour.	Convolvulaceae
Alangium sp.	Cornaceae (Alangiaceae)
Bryophyllum pinnatum Asch. & Schweinf.	Crassulaceae
Luffa cylindrica M.Roem.	Cucurbitaceae
Momordica cochinchinensis Spreng.	Cucurbitaceae
Dillenia sp.	Dilleniaceae
Euphorbia hirta L.	Euphorbiaceae
Euphorbia sp.	Euphorbiaceae
Mallotus sp. 1	Euphorbiaceae
Mallotus sp. 2	Euphorbiaceae
Chirita hamosa R.Br.	Gesneriaceae
Callicarpa sp.	Lamiaceae (Verbenaceae)
Gmelina sp.	Lamiaceae (Verbenaceae)
Mimosa invisa Mart. ex Colla	Leguminosae
Papilionoidea sp.	Leguminosae
Lygodium sp. 1	Lygodiaceae
Lygodium sp. 2	Lygodiaceae
Hibiscus sp.	Malvaceae
Grewia sp.	Malvaceae (Tiliaceae)
Melia azedarach L.	Meliaceae
Artocarpus heterophyllus Lam.	Moraceae
Ficus sp. 1	Moraceae
Ficus sp. 2	Moraceae
Ficus sp. 3	Moraceae

Ficus sp. 4	Moraceae
Streblus asper Lour.	Moraceae
Musa acuminata Colla	Musaceae
Psidium guajava L.	Myrtaceae
Oxalis corymbosa DC.	Oxalidaceae
Phyllanthus reticulatus Poir.	Phyllanthaceae (Euphorbiaceae)
Piper lolot C.DC.	Piperaceae
Bambusa sp.	Poaceae (Graminae)
Rubus molluccanus L. var. *alcaeifolius* (Poir.) Kuntze	Rosaceae
Mussaenda sp.	Rubiaceae
Neolamarckia cadamba (Roxb.) Bosser	Rubiaceae
Paederia foetida L.	Rubiaceae
Clausena lansium Skeels	Rutaceae
Zanthoxylum nitidum DC.	Rutaceae
Dimocarpus longan Lour.	Sapindaceae
Pouteria lucuma Kuntze	Sapotaceae
Solanum sp.	Solanaceae
Symplocos cochinchinensis S.Moore	Symplocaceae
Laportea interrupta (L.) Chew	Urticaceae
Lantana camara L.	Verbenaceae
Cissus modeccoides Planch.	Vitaceae

Table 8: Botanical taxon list of preliminary field determinations by Drs Nguyen Thi Mai Huong and Shawn O'Donnell on 18th & 19th September 2017.

Taxon spellings and author abbreviations follow the International Plant Names Index (IPNI) (www.ipni.org); family-level classification follows the most recent revision of the Angiosperm Phylogeny Group (APG IV, 2016; www.mobot.org/MOBOT/research/APweb/), with previous family-level placements and alternative family names from literature following in brackets.

7. CAPACITY BUILDING

Following from previous field seasons, Management Board staff members were encouraged to participate in all aspects of the fieldwork (and each of the research packages being undertaken). Vu Duy Linh, Le Thi Thanh Kim Hue, Nguyen Thi Loan, Vu Thi Lien, Vu Thuy Linh and Truong Thi Quynh Trang worked on site at Thung Binh 1, and in each of the three different landscape survey components of this this season's work (palynology, drone and molluscan) (e.g. figure 17). A representative from the Ninh Binh Provincial Museum, Department of Artefacts (Mr Pham Tuan Luan) also joined the excavation team during this season. While he had never dug before, he quickly proved himself to be a fast-and judicious learner (taking notes as he worked) and meticulous.

Figure 17: L.T.T.K Hue, V.T. Lien, Emilie Green and Aaron Redmond learning about UAV use before heading into the park.

During this season, project members have also been working closely with a PhD student from the Institute of History (Vo Thi Phuong Thuy). Thuy joined for the whole season with the objective of learning skills from the team and gaining familiarity with the Tràng An area where she is conducting her PhD research. Her experience is research-led, with many cross-overs to objectives held by the Project; however, it also exemplifies the kind of capacity building and opportunity for knowledge exchange.

Thuy's research focuses mainly on urban planning of the Hoa Lu citadel during the 10th Century, but also with wider area of the Tràng An complex and the vast valley at the east of the Tràng An. Although her special interest is in the 10th Century, the populated landscape at that time was result of a long-term interaction of human activities to the change of environment. Using different resources such as historical documents (written and spoken information), archaeological evidences (artifacts, remains relics), geographical data (terrain, soil, maps and aerial images), she is creating an overview of this landscape and the whole city when Hoa Lu was capital of the country, and try to understand how the planners used local and natural features to build the city.

During her first few days, Thuy was working in Thung Binh 1 with the team, firstly, re-opening Trench 1, which had been excavated during the last field season (March/April 2017) and then opening Trench 2. Through her involvement she is now confident about how to open a new trench, how to measure the trench, take notes and and records of an excavation as it proceeds; skills that she feels will be very useful when conducting excavations of her own for her PhD in near future.

Subsequent to her time on-site, Thuy was one of those who went into the field with the SUNDASIA topographic survey team, using an SUAV (drone) and total station. Through her involvement in this aspect of the project, Thuy learnt how to use a GPS and how to get accurate GPS points; how to program and control a drone; and skills in the use

of the total station: all techniques that will help her to map and visualize the landscape of the geographic area of her dissertation with high accuracy. She was also able, through her contacts, to assist in the digital terrain modelling objectives of the Project.

Finally, Thuy accompanied SUNDASIA's botanical team, and learnt how to set up pollen traps and why this is an important part of learning about vegetation change. She also learnt about prospective coring: how and where to core, and how to characterise changes in colour, and sediment content at different locations of the Trang An area. In her own research Thuy will need to analyse soil samples to better understand changes of sediment and the extent of human involvement in those changes.

8. CONCLUSIONS

8.1 *Landscape survey*

The UAV survey mission can be regarded as a success, despite some setbacks and initial difficulties. The team have gained a good understanding of the capabilities and limits of the UAV, how to operate it and plan efficient missions that yield robust results. More detailed analysis of the survey missions and consultation with peers over the coming weeks will provide further insights and contribute towards refinement of my survey methods. The team feel confident that they can survey a significant part of Trang An using UAV. The use of a second UAV, operated by Conor Graham (QUB) will significantly increase cover in a single season.

8.2 *Hang Thung Binh 1*

The provisional interpretation for Trench 2 is that it contains evidence from at least one episode of interment, possibly dating to the latest Neolithic or early Bronze Age and during (rather than a significantly later intrusion into) the accumulation of (E903) in 150/243 and 151/243. The limited quantity of human remains (and their confinement to extremities and isolated teeth) could imply that principal skeletal elements were lifted after interment for secondary burial elsewhere after a period of time.

There appears to have been a later disturbance of deposits in this part of the cave: in 150/244 and notably 151/244, which introduced glazed ware into seemingly largely intact deposits that have accumulated over the last 3000-4000 years, with late Neolithic occupational evidence (including bone, shell coarse, thick-walled ceramic sherds) within (E903). These deposits appear to have been underlain by an earlier Neolithic presence, as evidenced by fragments of Da But pottery that have been lifted from (E907) in both 150/243 and 151/243. For much of the season we had been expecting to uncover shell midden deposits comparable to those in the Institute trench and our own Trench 1, in the adjoining chamber. Such deposits did eventually appear (E908) was exposed first in the eastern half of 151/243 and in section can be seen to clearly slope towards the interior of the cave, possibly capped by a layer rich in degraded limestone. The upper-most spit of (E908) still contained sparse corded ware sherds, but was devoid of them in the spits beneath, suggesting either that this midden accumulated during the early Holocene (as proposed for the midden uncovered in the Institute, or potentially that it is comparable to the early Post-LGM midden in the SUNDASIA Trench 1; something we plan to investigate during the November/December 2017 season.

Midway through this season digging resumed in Trench 1. The aim of this additional work was to establish if any further deposits lay beneath the base of excavation

reached by the Project earlier in 2017. Work proceeded in square 151/251 only and extended recovery through an additional 40 cm of deposit. Large rocks (likely roof fall) impeded further work in this square; however, the incidence of finds had tapered off by this point, suggesting at least an hiatus in occupation had indeed been reached. Infrequent, bone, shell and charcoal samples were recovered, as were several pieces of flaked stone (*see* section 2.4). The weathered state of the bone from these lower contexts was notable and hints at a change and probably deterioration in conditions around the time of deposition; a feature which would accord well with the known antiquity of the overlying midden to c. 17.5-17.9 cal. Ka.

8.3 *Modern land snail (Cyclophorus sp.) survey*

The land snail survey this season took direct advantage of the summer monsoon conditions that allowed a comprehensive sample of specimens to be collected from a wide range of locations across the Tràng An core zone. These data will provide the basis from which will be obtained a locally nuanced calibration curve for dating the many *Cyclophorus*-dominated archaeological middens.

8.4 *Pollen trap, explorative coring campaign*

This season represented the first in the Project's palaeoenvironmental reconstruction programme, and base-line data sets needed to be established. Accordingly, pollen traps were deployed at 16 locations across Tràng An, with an emphasis on known archaeologically-productive sites. The full intended programme of pollen-traps and prospective coring was limited by conditions (notably, post-typhoon high water levels), but field survey observations have already made possible the beginnings of the first comprehensive botanical coverage for this property and, with data arising from the pollen traps over the coming year, crucial comparative material from which to assess the wider vegetative history of this landscape.

8.5 *Conservation programme summary*

Conditions hampered the setting of a full series of trail cameras this season, as had been our original intention. Even so, five cameras were ultimately positioned at points along the path from the Tran Temple and in the vicinity of Hang Boi. We were also able to establish that the system worked and anticipate being able to carry out a more systematic deployment during the November/December 2017 season.

Further collection and field analysis of small vertebrate remains from Hang Ang Noi marked our ongoing sample series at this locality and the strengthening of our amassed data on the health of the local environment, particularly given the site's comparative close proximity to one of the main routes through the Tràng An core zone.

The opportunity to advance jointly held ambitions in the endeavour to reintroduce primates (specifically) Delacour's Langur into Tràng An received a considerable boost this season through meetings between interested parties and the identification and vegetative survey of a prospective trial release-site on an island near to the Tràng An Visitor Centre.

8.6 *Capacity building*

The September 2017 season was the largest that the Project has fielded to-date: 22 people worked across four different research packages with diverse but integrated agendas. This

proved an excellent group environment within which to expand and exchange knowledge with members of the Management Board and other local colleagues.

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