SUNDASIA FIELD REPORT

(5th to 25th April 2018)

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Introduction

The April 2018 Sundasia field season comprised of three main work packages: 1) continuation of archaeological investigations of Thung Binh 1, 2) Landscape survey and, 3) Botanical and palaeoenvironmental survey. The progress of each work package is discussed, in turn, below.

1. EXCAVATIONS OF THUNG BINH 1

1.1 Summary of work

The first work package involved the continuation of excavations in Trench 2 at Thung Binh 1, on the north-western periphery of Tràng An, to recover the remainder of the human skeletal remains that were identified and partially recovered at the end of the November/December 2017 season. Our efforts in April 2018 with colleagues from the Archaeological Institute, Hanoi, focused in the mouth of the main chamber. Excavations recommenced at Thung Binh 1 on the 7th April 2018. Work on site continued until 24th April when the site was backfilled closed.

The programme of work began with the removal of backfill from the previous season (November/December 2017) in Trench 2 and then cleaning the base of the trench. The main objective of the season was to, if possible, uncover, record and successfully recover the remainder of the human skeleton that was partially excavated (as SF 5 – upper right arm and shoulder, and SF 8 – principally crania) in the preceding season. As such, the extension of Trench 2 eastward towards the cave mouth (hence T2EE – "East Extension") had to be done to satisfy two criteria. Firstly, to provide a practical area of excavation that would be likely to allow the retrieval of the remainder of skeleton (designated as SF 36) while (secondly) not undermining the large boulder situated to the northeast of the trench, for safety reasons. The northernmost portion of T2EE comprised of an extension 50 cm to the east from the slot excavated for the retrieval of SF8 (in 151/245) and 75 cm to the southeast, where the extension was lined out at an angle of 140/320 degrees (the hypothesised orientation of the skeleton, based on measurements from SF5). The longest edge of T2EE was 165 cm on the western edge of exposed section from the preceding excavations, where it joined the eastern angled cut via a right angle.

Excavation of T2EE proceeded following the natural stratigraphic boundaries identified in the previous excavations of the site. Deposit was removed by trowel and all buckets of sediment were dry sieved. Finds were retained and bagged. To avoid repetition of numbers from previous seasons, small find numbers began from SF20. Environmental samples, one per layer (and typically 1-2 litres) were taken from each stratigraphic unit. In brief, layers can be summarised as follows.

(E900) is essentially a disturbed surface deposit. Highly trampled, this layer was removed as a surface cleaning. (E901/E902) is the underlying layer and was found to be rather compact through trampling. Once loosened with a trowel, the deposit consisted of a friable silty clay, with occasional whole shell (principally *Cyclophorus* sp.) and shell fragments and angular limestone inclusions. Ceramic sherds were recovered at the interface with underlying E903 and F906. F906 (previously designated F902) occupied c. 60 cm of the northernmost portion of the extension and comprised of a calcreted layer, which was rich in ceramic. F906 is the same stratigraphic unit as E903 but located directly under a drip line and removed as a separate context, as per previous seasons. This required use of picks and cut down to the contact with the underlying E907.

The finds from E903 were consistent with previous seasons. The deposit consisted of dark yellowish brown silty clay (compact in places, likely through trampling at the cave entrance) with frequent potsherds and occasional large shells. Potsherds were mixed phase, comprising late Neolithic and younger – a large fragment of the more recent material – a decorated pot (SF20), was among the uppermost finds to be uncovered. A detailed study of this material is being carried out by N.T. Hao. Characteristic finds (based on previous seasons) included a shouldered axe (SF 23) from middle point of the southern boundary of the extension, several small beads and several isolated human phalanges (SF's 21, 26 x 3 elements, 28 and 29) and teeth (incisors, SF 24, 27 and 30; molar SF 22). Wherever possible at the trench any HSR were recorded as small finds and plotted in three dimensions. One assemblage (SF26) of potsherds and HSR phalanges was recorded in detail in the southwestern portion of the trench. E903 was excavated to the contact with underlying E907, across the surface of T2EE.

E907 represents a very diffuse and difficult to separate contact between overlying, clay rich, slope wash deposits, incorporating eroded fragments of Da But pottery, and the surface of a shell rich (principally *Cyclophorus* sp.) Palaeolithic midden (designated F907 for this season). Unsurprisingly finds incorporated a mix of these depositional events. E907 was removed across the surface of the trench, tracking the undulating surface of the midden and the presence (or more accurately, the absence) of ceramic in the sieves and the levels established from previous excavation of the site to determine the surface of F907. This approach proved fruitful as, barring one small sherd recovered from the surface of F907, the remainder of F907 proved to be devoid of ceramic. The excavation of F907 proceed in a series of spits, firstly to level off the undulating surface of the midden (F907.1) and then as 10cm units (F907.2 and 3) to excavate down to the remainder of the skeleton. F907 (characteristically) comprised of dark brown silty clay, friable in patches more clay rich in others abundant whole and broken shell. Finds included broken and burnt animal bone (remains of deer bones, Cervidae, appear abundant) and some remarkable stone tools.

1.2 Lithics from F907

The April 2018 excavations at Thung Binh 1 Cave yielded a sizeable stone tool assemblage, which included a groundstone shouldered axe (SF 23, above), several cores and core tools,

and many flakes. After excavation, lithics were gently washed with lukewarm water and a soft bristled toothbrush and left to dry in the sun. After drying, all specimens were photographed (from dorsal, ventral, and sometimes lateral angles) with a Fujifilm digital camera on a black velvet background with a scientific scale. Finally, all specimens were repackaged for shipping. Notably, several retouched and unretouched lithic blades were recovered from (F907) (**Figs. 1 and 2**).

Fig. 1, A (left) Blade with micro denticulation towards distal end (dorsal); B (right) Blade with micro denticulation towards distal end (ventral).

Fig. 2, A (left) Blade – sandstone (dorsal); **B** Blade – sandstone (ventral).

This is significant for two primary reasons. The first is that they represent, to the author's knowledge, the first blade blanks to be recovered from a site at Tràng An. The second reason is that, on a larger scale, recurrent blade core technology is extremely rare in mainland Southeast Asia. Initial consultations with Dr Tim Reynolds (Birkbeck, University of London), Dr Philip Nigst (University of Cambridge), and Dr Dong Truong Nguyen (Vietnam Institute of Archaeology) were fruitful, and further studies on blade elements of the Thung Binh 1 assemblage will help shed light on Pleistocene blade technology at Tràng An.

1.3 Human skeletal remains: SF36

The surface of the assemblage of bones from the postcranial skeleton (designated as SF36) was uncovered (principally bones of the leg, in the first instance) at a level of 31.25 (the top of crania SF8 was 31.27), towards the base of F907.4. SF 36 was orientated approximately 340 degrees and appeared to dip -15 degrees from north to south. From the south of T2EE, the distal elements of the leg were evident (both feet), in approximate anatomical order with elements of the leg, which ran approximately 40 cm to the north west of T2EE. Exposure of the highly fragmented rib cage, clavicle and remnant arm elements required excavation of the remainder of the eastern portion of 151/245 (from beneath and around the location of the block containing SF8), taken as F907.4. All in all, the bones appeared to be moderately well preserved – bones were reasonably diagnostic, exposed in plan, but had clearly been compressed and fragmented with many old breaks evident. Some effort was made to identify a grave cut, but none was apparent.

Excavation proceeded following the cardinal points, as F907.4-N, F907.4-E, F907.4-W and F907.4-S (recorded in plan 2.3) around SF36 to determine the maximum extent of the skeleton in plan and in section, and to allow reconciliation of any distal elements or fragments, should they be recovered at the sieves. This series was excavated to a depth of 31.15, where it was evident that much of the assemblage was "stacked" in section, rather than being distributed across the trench, in plan. After this depth, the series changed to F907.5-N, etc. These spits, however, were excavated beneath the presumed level of the SF36 to isolate the specimen and to aid the block lifting of portions of the skeleton. The volume of animal (i.e. non-human) bone fragments, including turtle and deer, increased markedly in the sieved spoil directly associated with SF 36.

On the 22nd April, SF 36 was planned and then ultimately lifted in six sections, 36.1-36.6 (**Fig. 3**). 36.1 comprised of a right femur, isolated from the main block of leg elements (36.3). This was lifted in two pieces, due to an old break to the middle of the diaphysis. 36.2 comprised of the bones of the feet, lifted as one block. 36.3 comprised of left and right tibiae and fibulae, left femur and bones from the ankle – the talus was clearly present. Some fragments of bones of the arm, apparently lying directly underneath this section were also apparent in the block. 36.4 consisted of the remnant bones of the hand and the arm. 36.5 was block lifted and incorporated the highly fragmented remains of the pelvis, as was 36.6 to recover highly fragmented ribs. The base of the trench was then investigated for any remnant bones to a maximum depth of 31.01 m. Bafflingly, vertebrae were not evident in any excavated block in plan and further investigation of each block section (see below) failed to yield any substantial evidence of these elements. Either these elements remain in situ, likely in an unexcavated section or may not be preserved (although this is perhaps unlikely).

Elements from SF 36 were given some opportunity to dry and received some cleaning and (chemical-free) curation on the 23rd April – measurements of the bones, wherever preservation allowed, were taken. Preservation was generally fragmentary, with many bones degraded, although in terms of state of chemical preservation, the subfossil remains showed very little to no parmineralisation for bones of terminal Pleistocene age. The bones most badly affected were the thinnest and most susceptible to fragmentation, the pelvis and scapula (see below). The epiphyses of long bones are also highly degraded, but initial indications were that it may be quite possible to reconstruct these portions of the bones with fragments collected from the adjacent spoil. All bone bags associated with excavation of SF36 were sorted through and all possible human bone fragments were removed and placed into storage at the Bai Dinh with SF8 (the cranial specimens from December 2017). Elements from the six major sections of SF36 are stored in the fridge unit at the Bai Dinh.

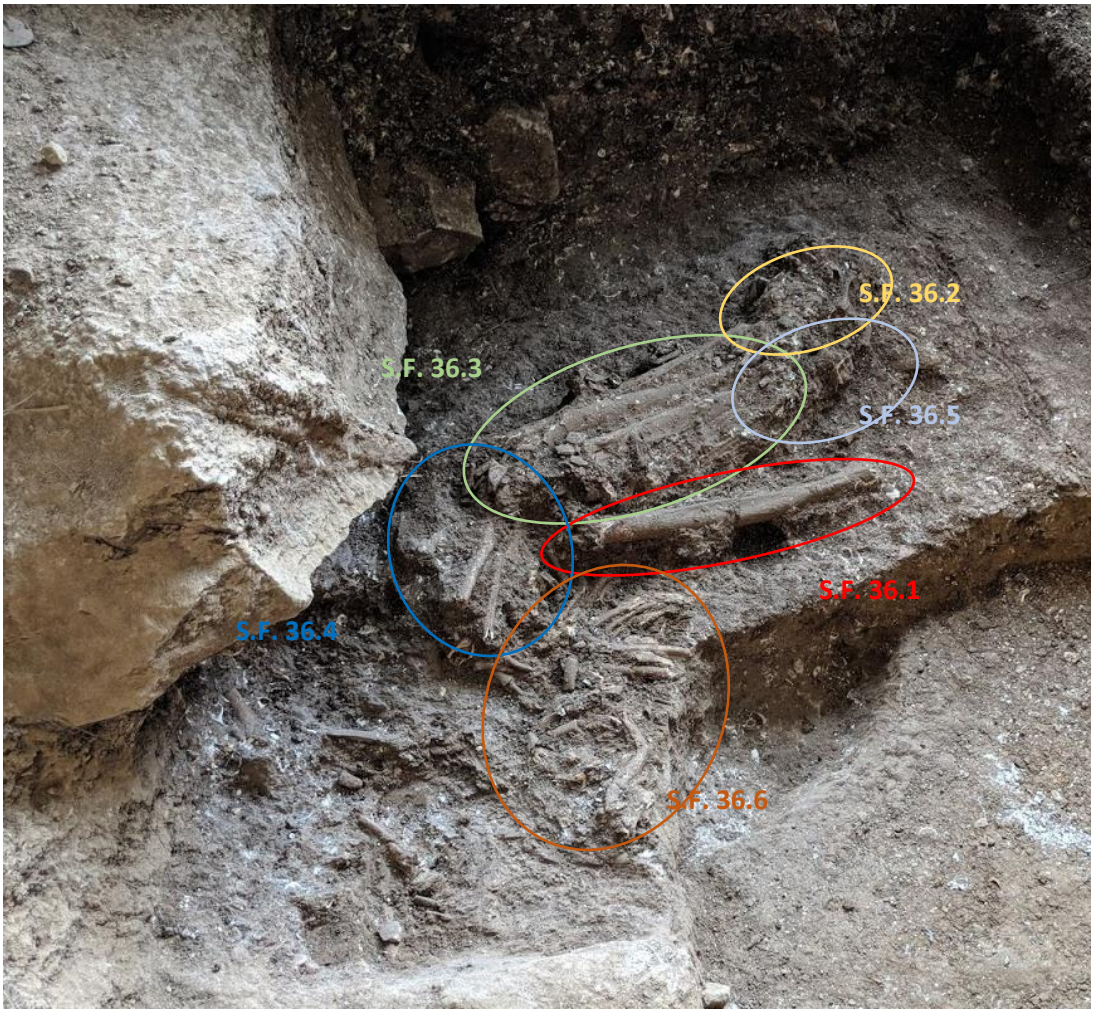
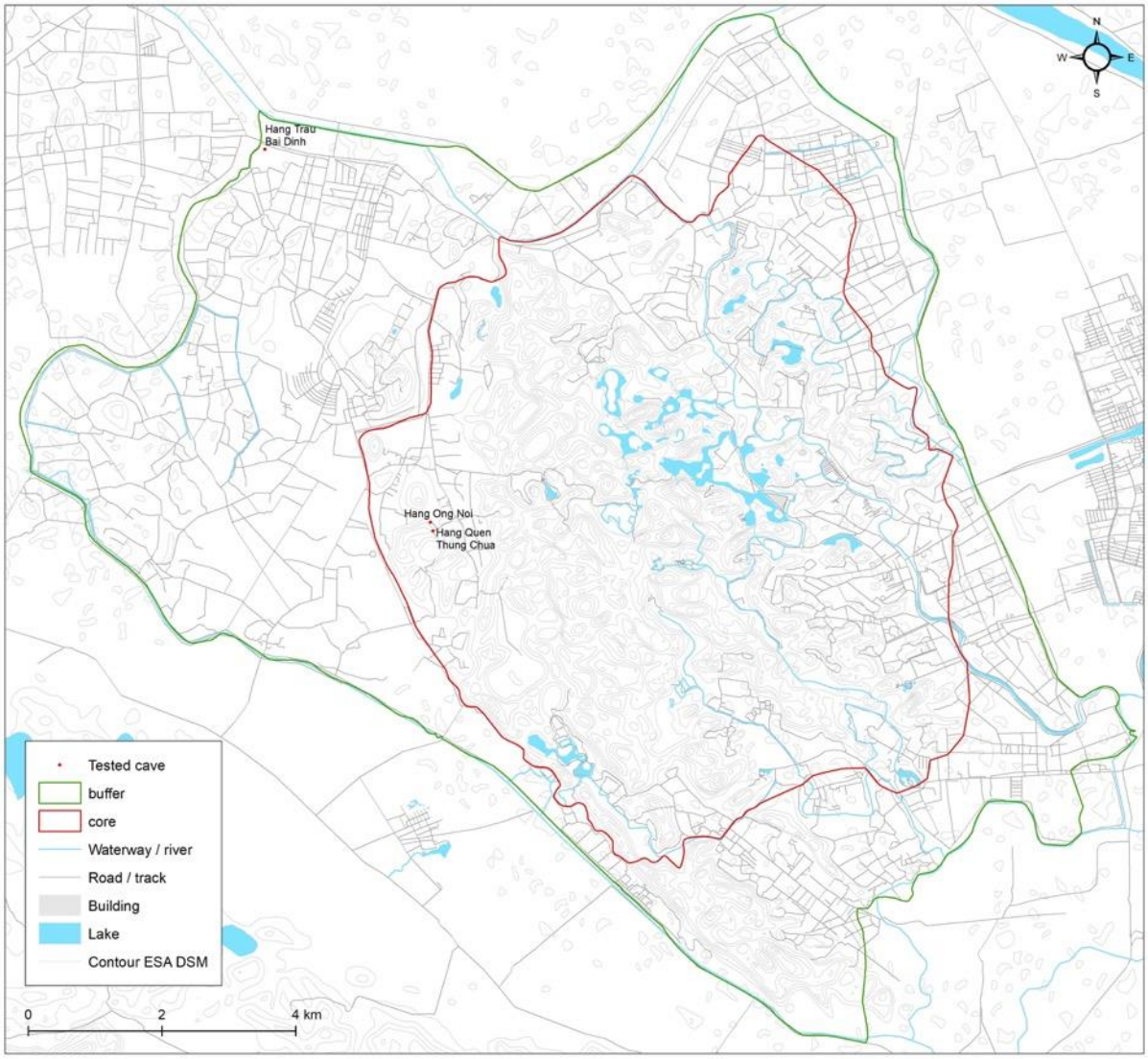


Fig 3. Location of blocks S.F. 36.1-6 as in context (E907.4) prior to lifting. **S.F. 36.1: Right Femur; S.F. 36.2: Feet and Ankle Bones; S.F. 36.3: Tibiae and Fibulae, Left Femur and calcaneus; S.F. 36.4: Arm and Hand Bones; S.F. 36.5: Pelvis; S.F. 36.6: Thoracic Bones.** (Illustration: RM).

2) Landscape survey and test-pitting



2.1 Test-pitting

Originally, three sites were selected and approved for testing during this season: Hang Trau Bai Dinh, Hang Nuoc and Hang Thung Ui. However, the latter two caves were not feasible for testing (see section on caves and rock shelters) and permission was given to select two alternative sites, Hang Quen Thung Chuan and Hang Ong Noi, both site are near Thung Chua Doline and were recorded during the March 2017 field season. Basic cave surveys and sketch plans were done for each cave using TST and DsitoX and will be processed at a later stage.

2.2 Hang Quen Thung Chua (HQTC18)

Hang Quen Chua is one of three caves that were recorded in March 2017 near the Thung Chua doline. The doline is a closed depression that was used for small scale agriculture in the past (pers. comm. Mr. Binh). Two foot paths lead into Thung Chuac over lower ridges in the north and the south that connect the taller karst peaks. The northern footpath leads mostly of bare limestone bedrock and large boulders that form natural steps. The limestone is polished in places from extensive use. Hang Quen Thung Chua is located at 65m asl along

the northern path and marks the half way point between the foot and saddle of the ridge. A small bamboo gate has been installed across the footpath below the last ledge before Hang Quen that did not exist in September 2017 (O'Donnell, pers.comm.). Hang Quen faces east and overlooks a poljie that lies between the central Trang An massive and Thung Chua. Thung Binh hill lies 1.5km to the northwest; Hang Boi and Hang Trong 2km to the east.

The cave consists of a single 4m by 6m chamber with a maximum ceiling height of 5m. The cave walls are covered with speleothems throughout and the floor is covered with a brown deposit and goat droppings. A small rift passage in the eastern corner of stops after 5m. An upper chamber c. 2.5m above the cave floor in the western corner featured a false calcite floor which has some ancient sediments with shell inclusions stuck to its underside. A small sample was taken for potential dating (Q2100).

The main chamber can be accessed via a low and wide mouth that slopes down from the outside. The mouth of the cave is located below an overhang that provides some shelter to a small natural level area. Two test pits were excavated in Hang Quen. Test pit 1 (TP1) was excavated in a raised area beneath the overhang. Test pit 2 was excavated inside the chamber in a sediment build-up in its western corner. A TST was set up and calibrated to a TBM that was marked on a large limestone boulder along the foot path at 65.65m asl (pending final calibration). After cleaning the surface from loose sediments and animal contamination, a 0.5mx0.5m northwest facing area was staked out for testing at 66.24m asl, with the prospect of extension should it become necessary. The surface was recorded at Two contexts were exposed during testing.

(H200) was a 2cm thick strong brown compact clayey silt with some darker patches caused by animal contamination (goat). A few sherds of historic ceramics and modern material in the form of molluscs, bone and plastic were recovered from this context. No environmental samples were taken due to modern contamination. (H201) was a 17.5cm thick layer of dark yellowish brown silty clay. It was slightly more compacted at the interface between (H200) and (H201). Apart from a small quantity of crushed shell and plant roots, (H201) was sterile. (H201) terminated on limestone at 66.03m asl. No environmental samples were taken due to the absence of archaeological material in the test pits.

Test pit 2 (TP2) was opened in an elevated area near the back of the chamber on the slope of a sediment cone that abutted against the cave wall. The chamber did not provide space for a total station and all levels were taken from a TBM inside the cave with a DistoX integrated laser distance meter, compass and clinometer at a marked TBM above the trench. Elevations are stated as below TBM. A thin layer of a firiable clay (H202) mixed with organic matter overlaid a single context (H203) consisting of a dark yellowish brown compact clay that extended to the base of the trench. This layer contained tree roots and a small quantity of historic pottery in its upper stratum but turned archaeologically sterile thereafter. The trench was excavated to a depth of xxm (to be determined) when a calcite deposit was reached on eastern side of the trench. The sediment on the western side was probed to a depth of xxm (to be determined) but was left in situ.

TP1 demonstrated a distinctive lack of substantial sedimentation immediately outside Hang Quen Thung Chua and with it a low possibility of finding archaeological remains. Other areas closer to the entrance may yield deeper sediments but their archaeological potential are currently deemed as low. The clay that was encountered in TP2 is likely to occupy most of the rear of the chamber. It seems to have been washed in via a now mud-chocked passage in the western corner of the chamber where the sediment build-

up is at its highest elevation. At this point, it is unlikely that archaeological remains are not present or survived in situ in Hang Quen Thung Chua.

2.3 Hang Trau Bai Dinh (HTBD18)

Hang Trau Bai Dinh is one of at least 3 caves that formed in an isolated limestone knoll on the northern boundary of the Trang An buffer zone. The cave consists of a single oval chamber (7.6m x 6.8 x 6m high) that can be accessed via two entrances. A small antechamber near the east entrance – now blocked by a brick wall - connects to a rockshelter that is used as temple dedicated to two female monks.

HTBD (TA89+) is mentioned in Annexx 3.3 (pgs.31 and 37) to the UNESCO dossier where testing was recommended due to the presence of Pleistocene sediments and some stone tools. The cave was initially visited during fieldwork in March 2017 and probed to a depth of 20cm producing historic pottery and bone fragments.

A 0.75x0.75m test pit (TP1) was opened near the western wall of the chamber that was subsequently extended to an additional adjacent pit of the same dimensions. Excavated to a depth of 1.2m but not bottomed, TP1 produced three contexts. (H300) reached a depth of 0.1m to 0.2m below surface and consisted of a strong brown silty clay with some limestone inclusions and ceramics of modern stone ware type and roof tile fragments. An ash lens in the east sections indicated the possible presence of a hearth. (H301) reached a depth of 0.4m in the western part of the trench and 0.15m in the east. The fill consisted of dark brown clayey silt with frequent sub-angular limestone inclusions. Apart from a singular piece of charcoal and two fragments of modern ceramics, (H300) was sterile.

An abrupt change in sedimentation marked the interface between (H302) and its overlaying stratum (H301). This context was excavated to a depth of 1.2m without reaching its bottom. The fill consisted of dark brown compact clay with frequent inclusions of ceramics and modern brick fragments. A cluster of medium to large limestone fragments that penetrated through all three contexts overlaid a 0.5m to 0.6m thick area of burning in the southern part of the trench at a depth of 0.45m. It extended 0.6m east to west and 0.35m from the southern section. The stones that were in direct contact with the hearth showed burning marks on their underside. Charcoal occurred frequently throughout the fill. A small void in the eastern part of the trench was exposed and extended to 1.2m below surface level. Excavation was stopped as this point due to presence of modern material at this depth and lack of appropriate tools to extend the trench in a manageable time frame.

Due to its proximity to the local water table as well as the rivers Song Hoang Long and Song Boi, it is likely that if Pleistocene sediments are preserved at HTBD they are likely buried at a greater depth, possibly below the current water table. Given the presence of at least 1.5m of compact clay overlaying any potential archaeological/ Pleistocene strata, which may also be water logged, reaching those layers would require considerable time and effort.

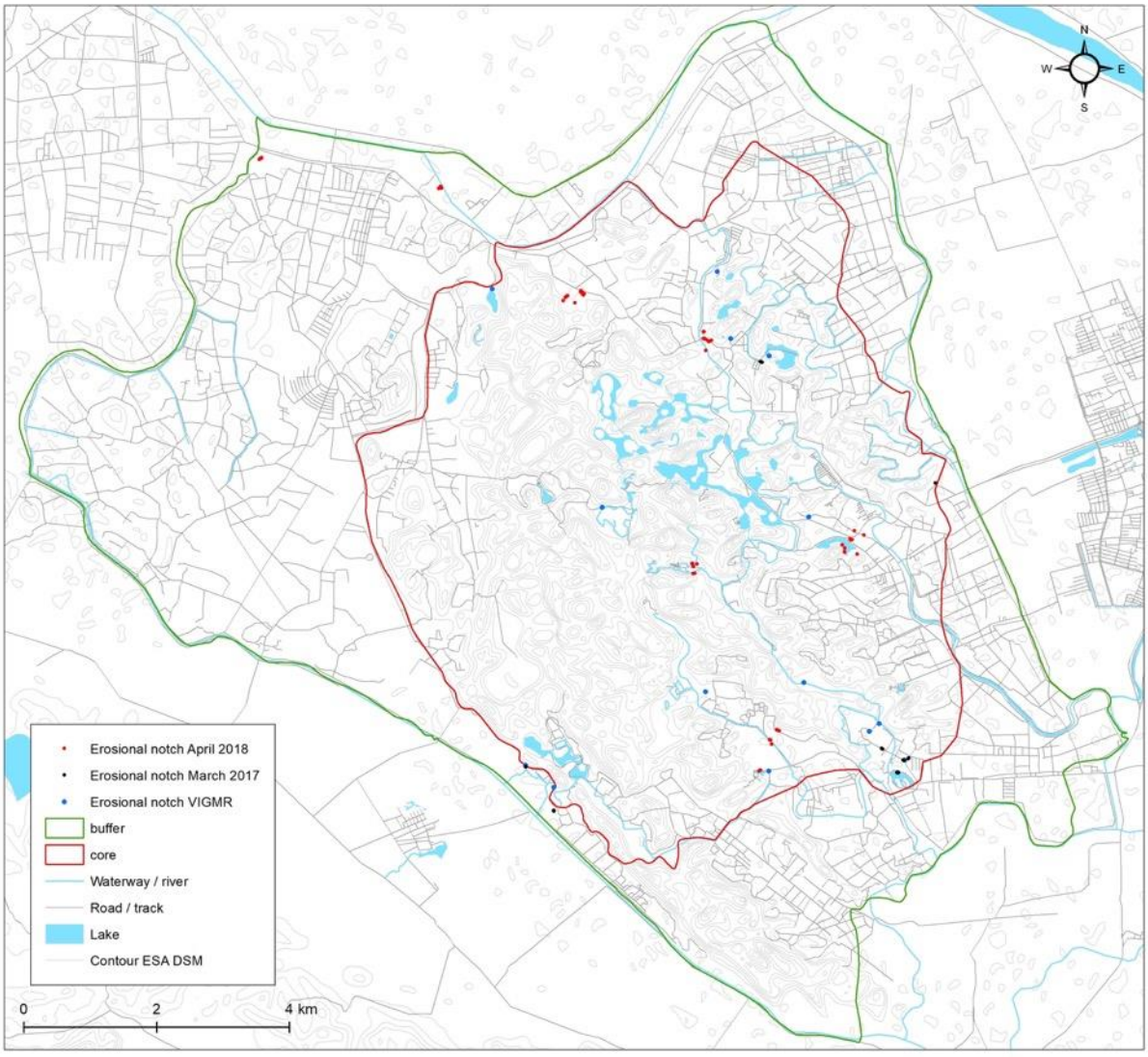
2.4 Hang Ong Noi (HBD18 – former Hang Bat Dua)

Due to a misreading of notes during field visit, Hang Ong Noi (HON) was mistakenly identified as the nearby Hang Bat Dua. Trench photographs are thus marked with HBD18 but should be interpreted as reference to HON. HON is part of the same group of caves as Hang Quen Thung Chua and lies 135m north of it at an altitude of 45m asl. The cave consists of a 2.2 m wide by 8 m long and 2 m high entrance chamber. At its rear is a 1.5 m high ledge that leads into a narrow short winding passage. At the end of the passage is a slightly

smaller chamber, measuring 3 x 3 m. Several smaller chambers connect to this chamber. Speleothems are present in the passage, inner chamber and its extensions.

Two 0.5m x 0.5m test pits (TP1 and TPS2) were excavated in HON in the rear chamber and entrance passage respectively. TP1 was excavated centrally in the first chamber. The area was cleared of any loose surface material and the pit was then excavated to a depth of xxm (to be determined) where the presence of large limestone blocks prohibited further excavation. The fill consisted of a single layer (H100) of strong brown friable clay. (H100) contained a small number of historic pottery and was sterile past a depth of xxm (to be determined). TP2 was excavated c 2m inside the cave mouth. The area was cleared from recent biological contamination prior to excavation. The fill consisted of a single layer (H101) of strong brown silty clay mixed with small angular stone and calcite fragments. The fill was extremely hard and sterile and efforts were stopped at a depth of 0.25m.

2.5 Erosional notch surveys



Erosional notch surveys were carried out along the western half of the core zone. At each location, three GNSS coordinates were recorded to sub 5cm accuracy to which a TST was

oriented. Elevations were recorded against ellipsoid datum, which will be reduced to asl elevations using the 140411 local Benchmark as a reference. Measurements were taken at three points on each notch feature: top of the notch, which marks the highest point of water level; the deepest penetration into the limestone, which marks the average water level and the base of the notch, where present. Where possible, several measurements were taken along more extensive erosional notches to detect possible vertical displacement of the feature. A limiting factor in the quantity of surveys was limited access to RTK and NTRIP at some locations and long-time sampling of at least 15-20min of observation per GNSS coordinate was required for post processing.

During one of the survey expeditions, courtesy permission from a local was asked to pass through private property to survey an erosional notch near Hang Luon water cave and Cai Ha mountain, which currently is subject to some controversy caused by the construction of a staircase and associated structures without permission on Cai Ha mountain. The local man refused the team access to the sea notch site, which was visited on March 25th 2017, claiming that the cave was under military control and thus was restricted. A heated debate ensued with between him and Miss Loan. At this point it seemed best to withdraw from the site to prevent further escalation.

2.6 Caves and rock shelters

Hang Nuoc, which was first noted during the September 2017 field season, was visited to prospect for potential archaeological testing, consisted of an extensive, partially flooded cave. A crawl underneath a boulder collapse leads into a spacious passage that extends in two directions as a roughly north to south oriented winding passage with varying ceiling heights. To the north, the ground inclines until dropping into a flooded passage after c. 20m. According to locals, this flooded passage resurges on the opposite side of the mountain. To the south, the passage can be followed for c. 50-60m where, past a particularly low crawl over a flat inclined bedding plane the passage meets with a slightly lower flooded passage. A colony of several hundred bats (*Hipposideros* sp.) inhabit Hang Nuoc. The cave did not present any potential for archaeological testing.

The Ui Valley rock shelter was first noted by R. Rabett during field work preceding the SUNDASI project and recorded during the November 2017 field season. The landscape team investigated the site to prospect for the possibility of archaeological testing. Two members of the team climbed to the base of the prominent overhang and found that the potential for the presence of archaeology was highly unlikely. The entire side of the slope abutting the cliff below the overhang consists of massive limestone boulders with occasional level areas that are covered only by thin layers of sediment.

A rock shelter site en-route to Tran temple was investigated for potential archaeology. A platform c. 10mX10m lies c. 1.2m above the local water level and consists mainly of alluvial sediments. Building rubble and a small rectangular foundation indicates the presence of a former structure on this site. A small cave south facing penetrates the limestone cliff underneath the rock shelter. It is currently less than a metre high and wide and c. 5m-6m deep. The ground consists of cracked alluvium and the cave is likely to be flooded periodically. The alluvium probably has obscured most of the cave passage and it is likely that the cave used to be a water cave.

Hang Beo was pointed out to the survey team during surveying of a notch site near Hang Trau Bai Dinh. A small west facing entrance at 5m asl measures 0.8m in width and 1.1m in height. It leads into a small entrance passage that turns abruptly southwest after 3m.

From there, the principal passage, 2m to 5m wide and 3m high, continues for 11m. Several small interconnected passages extend from the western wall at two levels with an accumulative length of 21m. A narrow rift passage extends east for 6.5m near the rear of the principal passage. This passage slopes down steeply to c. 2m below the floor of the principal passage and ends in small water filled chamber. The cave floor consisted of dry loose clay mixed with medium to large limestone fragments. Some modern looking pottery sherds and waste was noted. Albeit not tested, the archaeological potential of the cave appeared to be low. The cave was inhabited by a single bat.

Ao Beo was described by the same local man who pointed out Hang Beo as a deep vertical shaft on top of the HTBD limestone hill. Two team members climbed the hill in search of the cave and discovered a small entrance in a recess at 22m asl and 65m west of HTBD. A low south facing entrance measures leads into three chambers. All chambers are roughly round in plan and their floor is covered with medium sized limestone rubble. Chamber 1 (C1) forms an entrance chamber c. 1.5m to 2m below entrance level connected by a short, low and steep passage. C1 measures 5.5m by 3.6m and is 3m high.Chamber 2 (C2) is the largest chamber with maximum dimensions of 5.8m by 5.9m and a height of 4.7m. Its floor is c. 0.5m to 1m below the floor of C1 and oxbows back to it via a small window. It also functions as a connection between C1 and Chamber 3 (C3). A small passage in the northern extent of C2, 0.8m wide by 1.8m high ends after 5m.

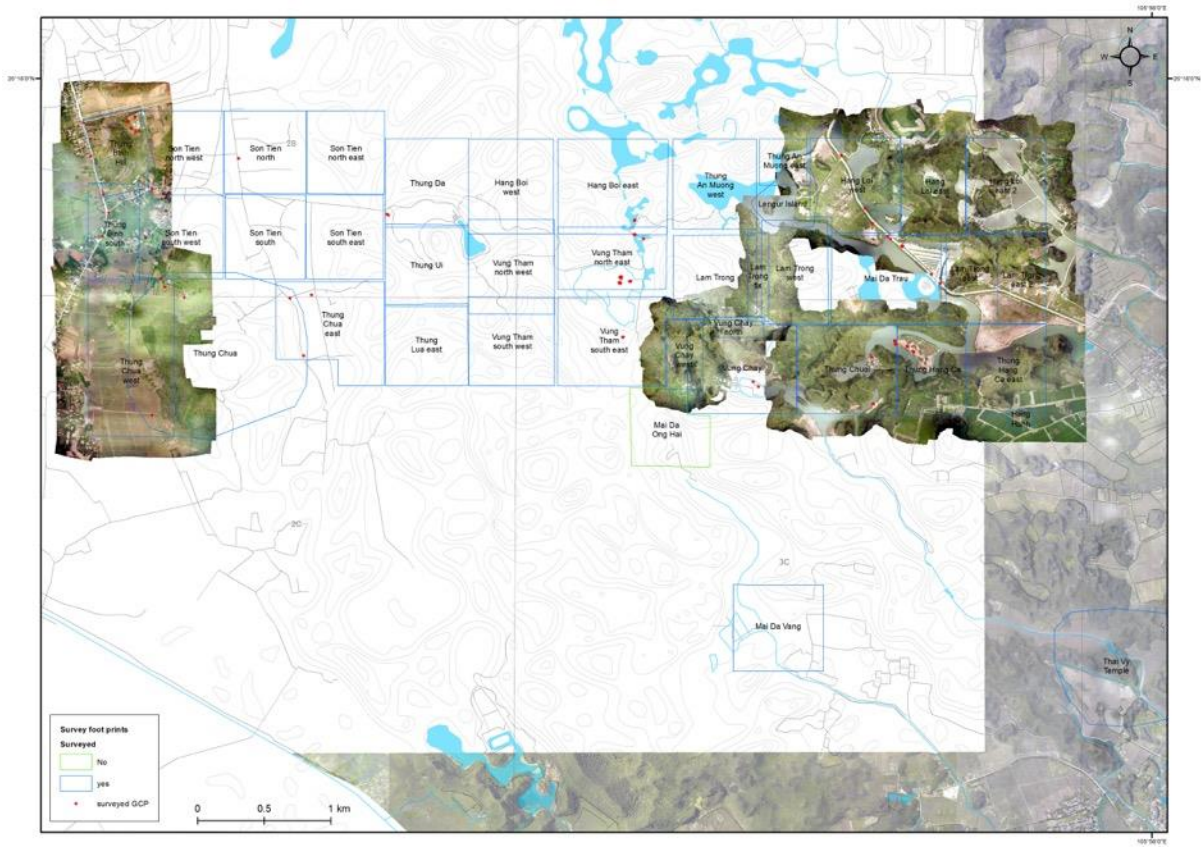
C3 measures 4.8m by 3.3m and is 4.6m high. The chamber connects to the entrance chamber in the south via small window. A 6m long vertical chimney in the northern end of C3 opens in small skylight. This is probably the deep vertical shaft described by the local man.

A strong smell of ammonia is present in Ao Beo and animal excrements occur frequently through the cave but are concentrated at the rear of the 5m passage the extends from C2.

A cat-like mammal inhabited the cave and is likely to be a civet cat. The local man later confirmed that he frequently encounters a civet cat in his nearby garden.

Fig. 4. Bat colony in Hang Nuoc.

2.7 UAV survey



Twelve UAV surveys were conducted at the western and eastern extend of the proposed corridor to complete the proposed survey corridor through the centre of the Trang An WHS core zone. Three areas were surveyed in the west, including a re-survey of Thung Binh hill, which suffered from insufficient overlap and focus issues. Three surveys served to close some holes in coverage around Vung Chay and east of Vung Tham. The remaining six areas in the east linked the UAV with the LiDAR data. The surveys covered 620ha increasing the total area of the east to west swathe to 1518ha, which represents 24.56% of the Trang An core zone. Additionally, the area around the mouth of Hang Thung Binh 1 was photographically surveyed to complete the survey of the interior of the cave and integrate it into the exterior model of the hill.

2.8 Hang Thung Binh 1 trench survey

Prior to the lifting of the HSR, the trench was photographically surveyed was an emphasis on the human remains. Parts of the surrounding cave wall were also integrated and it should be possible to combine the resulting model with the existing cave model. More than 360 photographs were taken to record the trench.

3) Palaeoenvironmental reconstruction

This report details the ongoing programme of reconstructing the vegetation history of Tràng An. This work was conducted from 5-24 April 2018 as part of the sixth field season of the SUNDASIA Project. The tri-partite sub-objectives of this season's work are first defined. Outcomes of the work in relation to these objectives are then presented.

The tri-partite sub-objectives of the April 2018 field season's botanical and palaeo-vegetational programme were:

- To collect herbarium specimens of plants to supplement existing pollen reference material curated by NTMH in Hanoi;
- To core Thung Ui using a machanised system capable of penetrating the thick laterite layers that have presumably accumulated within the late Holocene, with a hope that underlying these more recent sediments in a more organic sequence from the mid-Holocene and earlier;
- To core several known organic-rich sequences that we augered in previous seasons, namely Vung Tham and Vung Chay.

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

3.1 Herbarium specimens

Botanical collecting focused almost entirely on valley bottom habitats, which, at present, are often dominated by disturbed, edge-adapted and regrowth communities. Only fertile plants were collected; in addition to providing the potential to extract pollen for reference collections, this is to aid in identification, and in light of the fact that many herbaria are unwilling to accession sterile material. Three full days were allocated to plant collecting, and supplemented with collections made *ad hoc* en route to, or at, coring sites. Figure 1 shows Nguyen Thi Mai Huong collecting a *Solanum* sp. at Thung Nang. A total of 54 plants were collected. Five replicates were made of each of these collections: three will remain in-country, which NTMH will distribute to local herbaria; the remaining two replicates of each collection will be shipped to the UK for accessioning within the Herbarium at the Royal Botanic Gardens, Kew, as well as for incorporation into a planned SUNDASIA Project herbarium. Key data for these collections are presented in Table 1; full data are tabulated in an Excel spreadsheet which is curated within project digital archives. Additionally, a project page on the citizen science platform, iNaturalist, was established, with 50 of the plant collections forming observations, as well as several other observations of flora and fauna encountered throughout the course of fieldwork: https://www.inaturalist.org/projects/sundasia.

Fig. 5 NTMH collecting a species of *Solanum* (collection number SAO 0025) at Thung Nang on 8 April.

Table 1 Herbarium specimens made during April 2018.

Date	Field ID	Collection no.	Locality
07/04/2018	*Saraca dives* (Leguminosae)	NTMH 0001	Thung Ui
07/04/2018	*Breynia* sp. (Phyllanthaceae)	NTMH 0002	Path from Thung Ui to Vung Tham
07/04/2018	*Sterculia lanceolata* (Malvaceae)	SAO 0021	Path from Thung Ui to Vung Tham
07/04/2018	*Rauvolfia* sp. (Apocynaceae)	NTMH 0003	Path from Thung Ui to Vung Tham
08/04/2018	*Boehmeria* sp. (Urticaceae)	SAO 0022	Dong Trong
08/04/2018	*Polygonum* sp. (Polygonaceae)	NTMH 0004	Dong Trong
08/04/2018	Cyperaceae sp.	SAO 0023	Dong Trong
08/04/2018	*Heliotropium indicum* (Boraginaceae)	NTMH 0005	Dong Trong
08/04/2018	*Maclura cochinchinensis* (Moraceae)	SAO 0024	Thung Nang
08/04/2018	*Broussonetia* sp. (Moraceae)	NTMH 0006	Thung Nang
08/04/2018	*Solanum* sp. (Solanaceae)	SAO 0025	Thung Nang
08/04/2018	*Gardenia* sp. (Rubiaceae)	NTMH 0007	Thung Nang
08/04/2018	*Marsdenia tinctoria* (Apocynaceae)	SAO 0026	Thung Nang
08/04/2018	*Sauropus* sp. (Phyllanthaceae)	NTMH 0008	Thung Nang
08/04/2018	*Melia azedarach* (Meliaceae)	SAO 0027	Bich Dong
09/04/2018	*Tarenna* sp. (Rubiaceae)	NTMH 0009	Hang Trau Bai Dinh
09/04/2018	*Clerodendrum* sp. (Lamiaceae)	SAO 0028	Hang Trau Bai Dinh
09/04/2018	*Leonurus* sp. (Lamiaceae)	NTMH 0010	Hang Trau Bai Dinh
09/04/2018	*Polygonum* sp. (Polygonaceae)	NTMH 0011	Hang Trau Bai Dinh
09/04/2018	*Polygonum* sp. (Polygonaceae)	SAO 0030	Hang Trau Bai Dinh
10/04/2018	*Abutilon indicum* (Malvaceae)	NTMH 0012	Hang Trau Bai Dinh
10/04/2018	*Desmos chinensis* (Annonaceae)	SAO 0031	Hang Trau Bai Dinh
11/04/2018	*Catunaregam spinosa* (Rubiaceae)	NTMH 0013	Quen
11/04/2018	*Psychotria* sp. (Rubiaceae)	SAO 0032	Quen

11/04/2018	*Mallotus* sp. (Euphorbiaceae)	NTMH 0014	Quen
11/04/2018	*Alpinia* sp. (Zingiberaceae)	SAO 0033	Quen
11/04/2018	*Clerodendrum* sp. (Lamiaceae)	NTMH 0015	Quen
11/04/2018	*Callicarpa* sp. (Lamiaceae)	SAO 0034	Quen
11/04/2018	*Elaeocarpus* sp. (Elaeocarpaceae)	NTMH 0016	Thung Ui
11/04/2018	*Oxalis debilis* (Oxalidaceae)	SAO 0035	Thung Ui
11/04/2018	*Sterculia lanceolata* (Malvaceae)	NTMH 0017	Thung Ui
11/04/2018	*Crotolaria* sp. (Leguminosae)	SAO 0036	Thung Ui
12/04/2018	*Neolamarckia* sp. (Rubiaceae)	NTMH 0018	Ninh Hai (near Vung Chay)
12/04/2018	*Pterolobium* sp. (Leguminosae)	SAO 0037	Bai Dinh Pagoda
13/04/2018	Rosaceae sp.	NTMH 0019	Ninh Hai (Den Thai Vi)
13/04/2018	*Eclipta prostrata* (Asteraceae)	SAO 0038	Ninh Hai (Den Thai Vi)
13/04/2018	Boraginaceae sp.	NTMH 0020	Ninh Hai (Den Thai Vi)
13/04/2018	Portulacaceae sp.	SAO 0039	Ninh Hai (Den Thai Vi)
13/04/2018	*Hedyotis* sp. (Rubiaceae)	NTMH 0021	Ninh Hai (Den Thai Vi)
13/04/2018	*Polygonum* sp. (Polygonaceae)	SAO 0040	Ninh Hai (Den Thai Vi)
13/04/2018	*Hygrophila* sp. (Acanthaceae)	NTMH 0022	Ninh Hai (Den Thai Vi)
13/04/2018	*Tirpitzia* sp. (Linaceae)	SAO 0041	Ninh Hai (near Den Thai Vi)
13/04/2018	*Mussaenda* sp. (Rubiaceae)	NTMH 0023	Ninh Xuan (Hanh Cung Vu Lam)
13/04/2018	*Diospyros* sp. (Ebenaceae)	SAO 0042	Ninh Hai (Hang Dai)
13/04/2018	*Dracontomelon* sp. (Anacardiaceae)	NTMH 0024	Quen
13/04/2018	Urticaceae sp.	SAO 0043	Ninh Xuan (Hanh Cung Vu Lam)
16/04/2018	Annonaceae sp.	NTMH 0025	Thung Ui
16/04/2018	Leguminosae sp.	SAO 0044	Thung Ui
16/04/2018	Apocynaceae sp.	NTMH 0026	Thung Ui
17/04/2018	*Impatiens bonii* (Balsaminaceae)	SAO 0045	Ninh Hai (Den Tran)
17/04/2018	*Impatiens* sp. (Balsaminaceae)	NTMH 0027	Ninh Hai (Den Tran)
22/04/2018	*Mitrephora* sp. (Annonaceae)	SAO 0046	Ninh Hai (Den Tran)
22/04/2018	Magnoliopsida - unknown eudicot	SAO 0047	Ninh Hai (Den Tran)

3.2 Mechanised coring

Mechanised coring in Thung Ui was conducted on 16 April adjacent to the TUA1 site of exploratory augering in November/December 2017. This site was selected because of the localised relatively organic and waterlogged sediments at the surface. This is also the deduced locale of the spring that Manh anecdotally advised us has naturally fed the eastern half of the valley prior to construction of the artificial lake that now occupies this half of the valley. The rationale behind this site selection is that position of the core here has the greatest chance of recovering an organic-rich, waterlogged sediment sequence of significant age, even if it is overlain by a substantial depth of recent laterites and spoil from excavation of the lake basin. Figure 2 shows the drilling rig as setup on site; Figure 3 shows NTMH and SAO recovering an extruded core from one of the initial two-metre long plunges through the upper laterite portion of the sequence. In total, 13m of deposit depth was drilled, the upper nine metres of which consisted of laterites with almost no organic content (Table 2). As it was deemed on sight by NTMH and SAO that this portion of the sequence contains little palynological potential, core sections for the upper five metres were photographed and described, but not retained. Core recovery began from a depth of five metres. Laterites continued until a depth of nine metres, where organic content appears to increase. The

tentative hypothesis is that the 9-13m depth portion of the sequence corresponds to the early-mid Holocene when sea-level and water tables were higher, and climate was wetter. This hypothesis will be tested by radiometric dating and palynological analyses.

Fig. 6. Coring setup and technicians on site at Thung Ui on 16 April.

Table 2 Core stratigraphy and accessioned environmental numbers for the Thung Ui core made on 16 April.

Depth (cm)	Descriptioin	Colour	Enviro. #
0-30	Sandy, silty clay	2.5Y/5/6 light olive brown	n/a
30-500	Clay with coarse sand-sized rotting angular limestone inclusions	2.5Y/7/8 yellow	n/a
500-530	Clay with coarse sand-sized rotting angular limestone inclusions	2.5Y/7/8 yellow	R2407
530-600	Clay	2.5Y/7/8 yellow	
600-700	Clay	2.5Y/7/8 yellow	R2408
700-800	Clay	2.5Y/7/8 yellow	R2409
800-830	Clay	2.5Y/7/8 yellow	R2410
830-900	Clay with some redox	2.5Y/5/6 light olive brown	
900(?)-1086	Organic clayey silt	5Y/4/3 olive	R2411
1086-1100	Silty clay	5Y/5/6 olive	
1100(?)-1252	Organic clayey silt with angular limestone sand inclusions	5Y/4/2 olive gray	R2412
1252-1300	Clay	2.5Y/5/6 light olive brown	

Figure 1 NTMH and SAO recovering a core section of the upper laterites at Thung Ui on 16 April.

3.3 Manual coring

In addition to the mechanised core made at Thung Ui, three additional cores were made during the April fieldseason using a manually operated Livingstone corer. As at Thung Ui, site selection in two of the manually cored sites – Vung Tham and Vung Chay – was driven by exploratory augering during the November/December 2017 season. The third site from which a core was made using the Livingstone corer – Dong Trong – is at the upper end of the waterway accessed via boat from Bich Dong, and was identified based upon consultation of VIGMR's 'Landscape Map' in Annex 3 of the UNESCO dossier, as well as visual inspection of surface sediments and vegetation during a visit to the site for plant collecting earlier on in the season. All three sites produced cores with sediment sequences in which organic units predominate. Pollen preservation is expected to be sufficient to produce proxy vegetation histories from each of these cores. Collectively, and in combination with the Thung Ui core, it is anticipated that the entirety of the Holocene, as well as some of the terminal Pleistocene, is contained within these cores. Figures 4, 5 and 6 show representative sections of the cores from Vung Chay, Vung Tham and Dong Trong, respectively; Tables 3, 4 and 5 contain descriptive data of the respective sediment sequences that were recovered.

Vung Chay core

Figure 2 Core from Vung Chay deposit depth 102-204cm (top at right, base at left), which corresponds, due to compression, to core depths 49-105cm (R2403).

Table 3 Stratigraphic and lithologic description of Vung Chay core; core depths differ from deposit depths due likely to compression.

Depth (cm)	Description	Colour	Enviro. #	Deposit depth (cm)
0-7	Oxidised clayey silt with plant rootlets	7.5YR/4/4 dark brown	R2402	0-102
7-22	Clayey silt	10YR/4/2 dark grayish brown		
22-49	Silt with flecks of shell & hummified plant fragments	10YR/3/1 very dark gray		
49-96	Clayey silt with large, partly hummified plant fragments	10YR/3/1 very dark gray	R2403	102-204
96-105	Clayey silt	5YR/5/2 reddish gray		
105-180	Clayey silt	5YR/5/2 reddish gray	R2404	204-306
180-277	Clayey silt	5YR/5/2 reddish gray	R2405	306-408
277-360	Clayey silt	5YR/5/2 reddish gray	R2406	408-510

Vung Tham core

Figure 3 Core from Vung Tham deposit depth 200-300cm (top at right, base at left), which corresponds, due to compression, to core depths 39-120cm (R2414).

Table 4 Stratigraphic and lithologic description of Vung Tham core; core depths differ from deposit depths due likely to compression.

Depth (cm)	Description	Colour	Enviro. #	Deposit depth (cm)
0-8	Organic silt & decaying plant fragments	n/a	R2413	0-100
8-17	Silty clay	2.5Y/4/2 dark gray brown		
17-30	Silty clay, redoxed	5Y/4/3 olive		
30-39	Silty clay, reduced	10YR/4/2 dark gray brown		
39-61	Clayey silt with large, decaying woody plant fragments	10YR/4/2 dark gray brown	R2414	100-200
61-120	Clayey silt	5Y/4/1 dark gray		
120-220	Clayey silt with bark & small shell fragments	5Y/4/1 dark gray	R2415	200-300
220-225	Clayey silt	5Y/4/1 dark gray	R2416	300-382
225-260	Clayey silt with limestone sand	5Y/4/3 olive		
260-282	Silty clay with fine gravel-sized limestone inclusions	5Y/5/3 olive		

Dong Trong core

Figure 4 Core from Dong Trong deposit depth 100-200cm (top at right, base at left), which corresponds, due to compression, to core depths 21.5-83cm (R2418).

Table 5 Stratigraphic and lithologic description of Dong Trong core; core depths differ from deposit depths due likely to compression.

Depth (cm)	Description	Colour	Enviro. #	Deposit depth (cm)
0-2	Decaying plant matter	n/a	R2417	0-100
2-12	Clay with some oxidation around rootlets	2.5Y/3/2 brownish black		
12-21.5	Organic silt with fine rootlets & charcoal	7.5YR/3/2 brownish black		
21.5-27	Organic silt with fine rootlets & charcoal	10YR/4/1 brownish gray	R2418	100-200
27-62	Silty clay with localised occurences of decaying plant & limestone	7.5YR/3/2 brownish black		

62-83	Silty clay with localised occurences of decaying plant, limestone & angular fine gravel	10YR/4/2 grayish yellow brown		
83-139	Silty clay with localised occurences of decaying plant, limestone & angular fine gravel	10YR/4/2 grayish yellow brown	R2419	200-300
139-164	Clayey silt with limestone sand & inclusions of decaying limestone	2.5Y/4/2 dark grayish yellow		
164-198	Clayey silt with limestone sand & inclusions of decaying limestone	2.5Y/4/2 dark grayish yellow	R2420	300-361
198-236	Silty clay, becoming more clayey with depth	2.5Y/4/6 olive brown		

Finally, Figure 6 is a map of Trang An which includes the locations of all herbarium specimens (red dots) and all four cores (black dots with labels) described in the text.

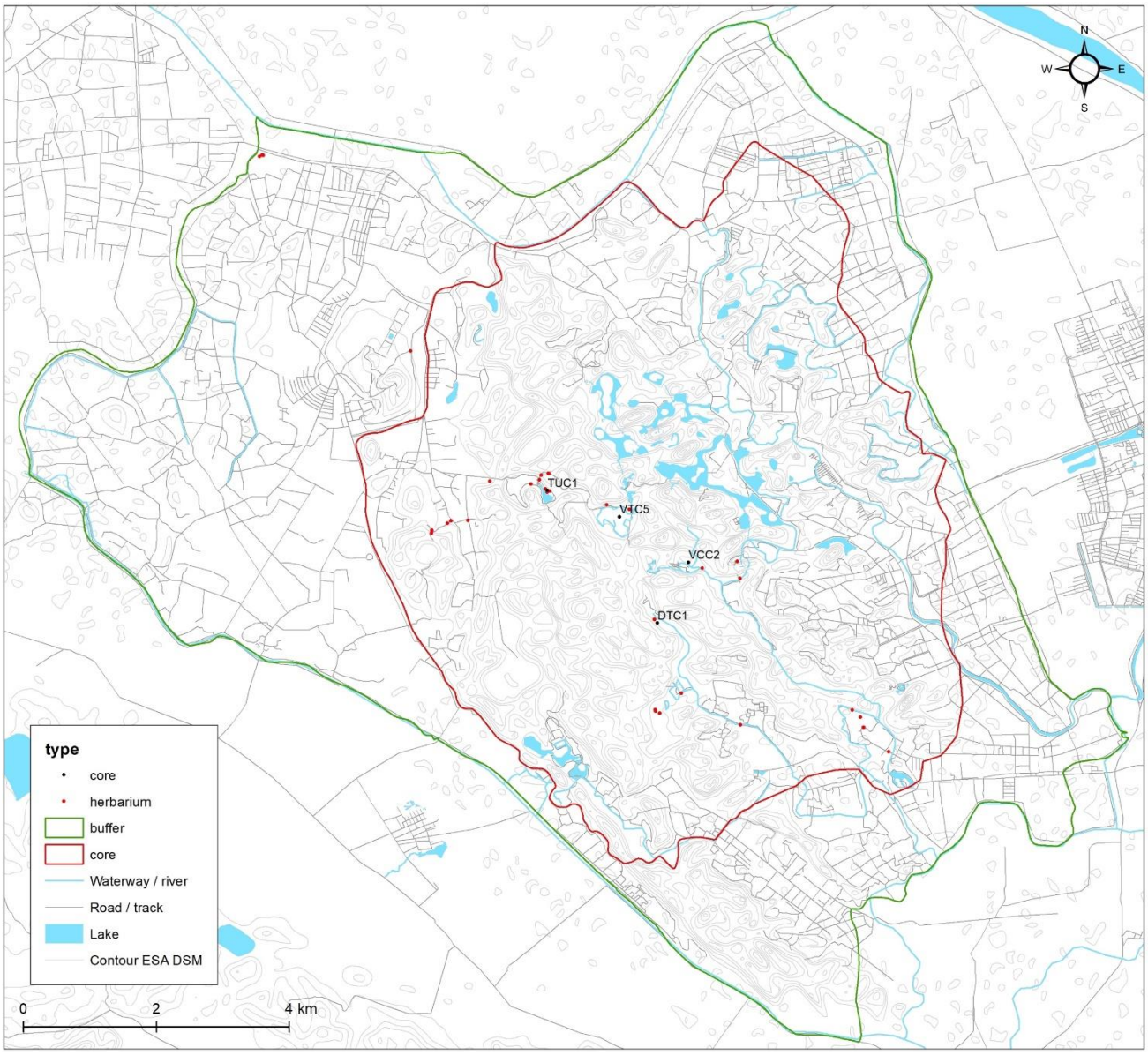


Figure 5 Map of Trang An with plotted locations of all herbarium collections (red dots) and the four cores (black dots) mentioned in text.