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Contents

A Cultural and Environmental Monitoring of the UNESCO World Heritage Site of Lumbini, Nepal

Coningham, R.A.E., Schmidt, A. & Strickland, K.M.S

1. Introduction

Although the UNESCO World Heritage Site of Lumbini is a major centre for Buddhist and Hindu pilgrims, as well as an international tourist attraction, the number of visitors, their behaviour on site, and the impact of this upon the site has never been recorded intensively. In 2001/02 an eight month survey of visitor activity and environmental conditions at Lumbini was carried out by a team of British archaeologists in conjunction with the Department of Archaeology, Government of Nepal and the Lumbini Development Trust, building upon an earlier UNESCO reactive monitoring mission in 2000 (Coningham & Milou 2000). The objectives of this intensive survey were to assist the national authorities in collecting baseline visitor movement and practices data, and environmental conditions, and to assist with the planning, development, management and conservation of the Sacred Garden.

In particular, this data was intended to assist the design process for the new Maya Devi Temple, at that time not yet constructed, (for example, most important features, time spent on site, or wind speed), as well as mitigating possible threats to conservation of the archaeological remains (such as daily numbers, humidity, water levels, rainfall, and temperature).

2. Methodology

The environmental survey was conducted from early September 2001 until late April 2002, a total period of eight months; while the visitor survey began in October 2001, and was incomplete for both December and January - a total of five months. During this time, 10 separate sets of data were recorded at the site, five cultural and five environmental. Unfortunately, due to visa extension difficulties, no data was recorded for the month of January.

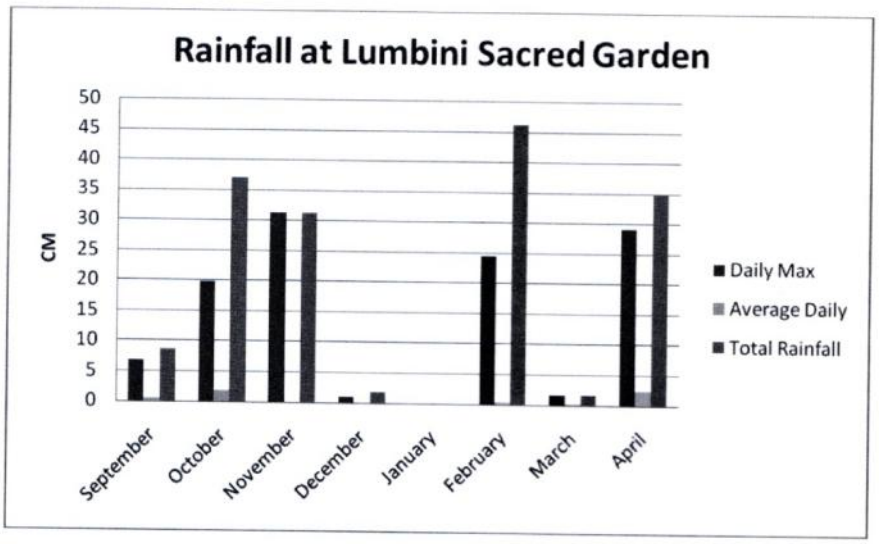
Environmentally, temperature, rainfall, humidity, wind speed and water level were all recorded. Temperatures (degrees centigrade) were recorded (three times a day) in three locations, outside the Temple, inside the Temple and, wherever possible, close to the Marker Stone chamber. Rainfall was recorded at the site in a rain gauge once every day, while humidity was recorded using a Cambridge KE model 3000 three times a day at three locations, outside the Temple, inside the Temple and, when possible, close to the Marker Stone chamber. Wind speed was recorded three times a day, also using the Cambridge KE model 3000 - on at least one occasion the wind speed was too strong (and dangerous) to allow recording. The water level within the Shakya Tank was also recorded daily, measuring below the uppermost brick of the Tank's north-west corner. In addition, we also recorded the daily water level in the Temple inspection pit, measuring below the uppermost brick of the pit's north-west corner.

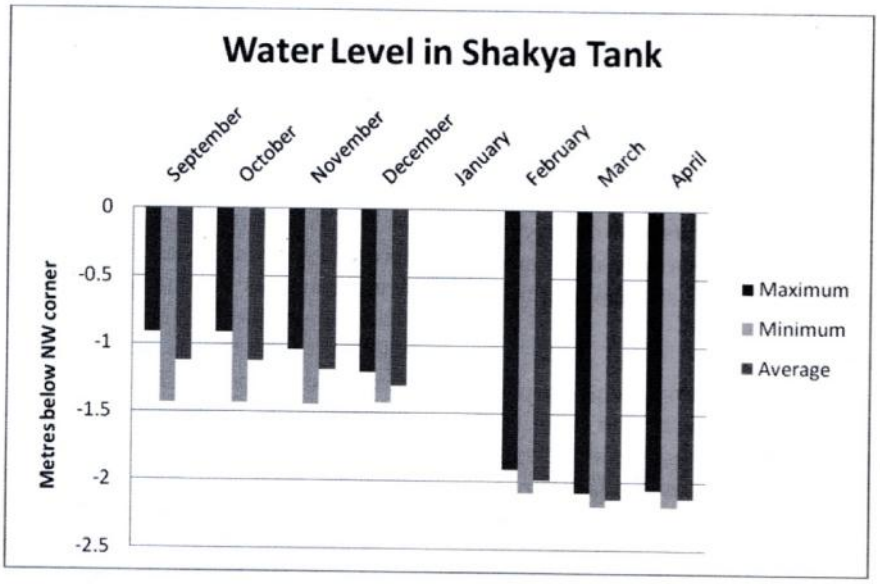
Five further separate sets of data were recorded for visitor activity; visitor numbers, the average amount of time spent on site, the highest three nationalities to visit the site, the highest two religions to visit the site and the visitor's perceptions of the most important features of the site. Visitor numbers were recorded for each survey day and monthly projections provided, figures also logged included maximum and minimum daily counts. Further information was logged through a sampling strategy of interviewing and monitoring every tenth

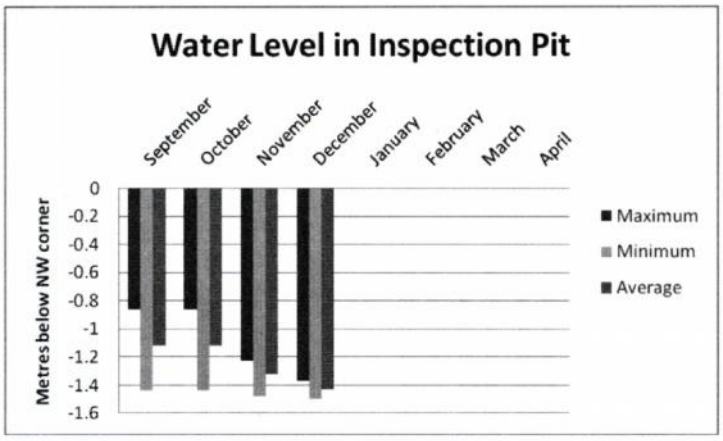
visitor to the site, recording nationality, religion, time spent on site and within Lumbini, and perceptions of the most important feature of the site.

3. Results

3.1: The Environmental Results The Environmental data provided a clear indication of the difficulties faced in conserving the archaeological remains, and in the design of the new Temple. The average monthly rainfall ranged between 0.3 cm and 37.1 cm. The heaviest daily rainfalls recorded were 31.4cm on 06.11.2001, 24.5 cm on 11.02.2002, 29.1 cm on 02.04.2002, and 19.8cm on 04.10.2001. It is important to note that this eight month survey did not coincide with the monsoon season, and the rainfall and water levels would undoubtedly have been far higher during the period of June through to the end of August.

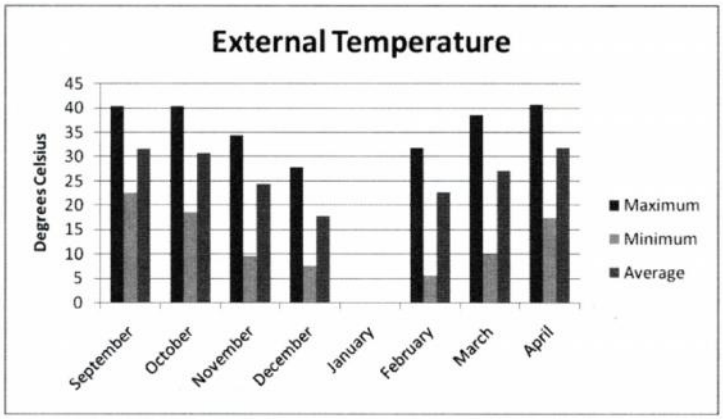


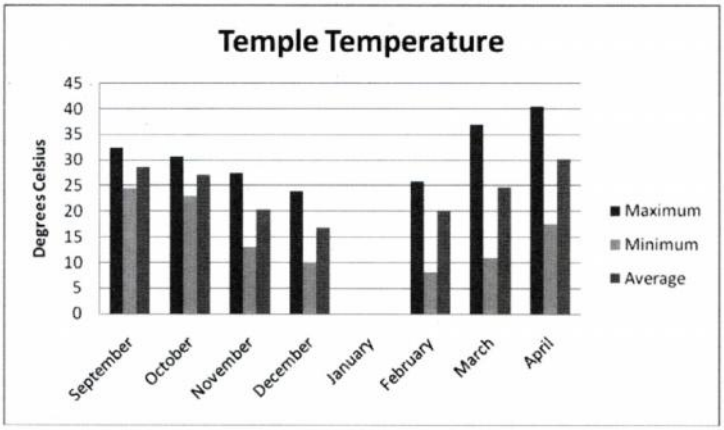




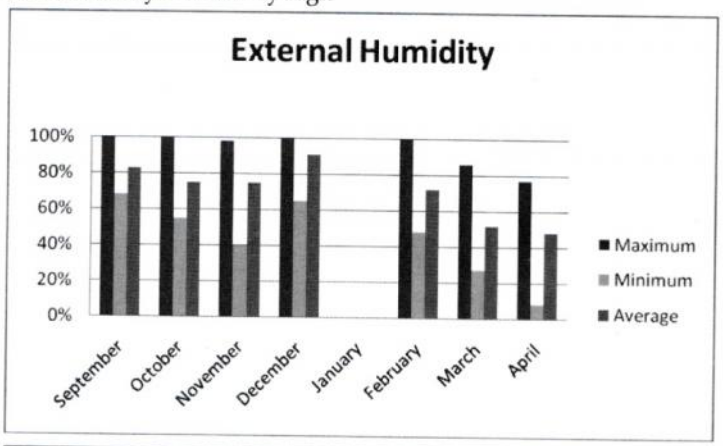
The inspection pit within the Maya Devi Temple was filled in by the Lumbini Development Trust in January of 2002, hence the lack of data from that point onwards.

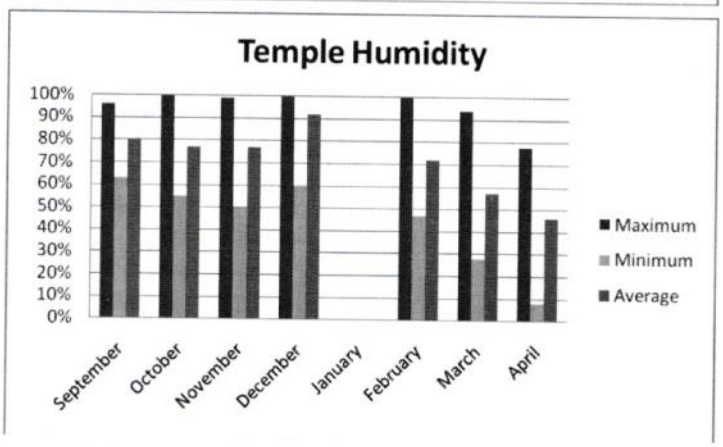
Monthly temperatures fluctuated between an average 17°C and 31.6°C, with a daily maximum of 40.4°C and minimum of 5.5°C. Interestingly, the interior of the Temple experienced less daily variation than outside.



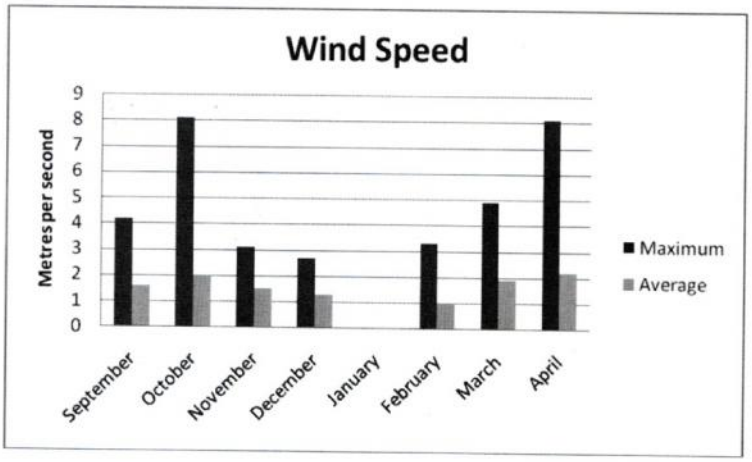


Monthly humidity percentages ranged between 100% and 40% - the humidity of the interior of the Temple and the Marker Stone chamber was very similar to the outside humidity. These very high humidity readings will present potential conservation problems if the Temple is entirely enclosed and may encourage the organic growth.





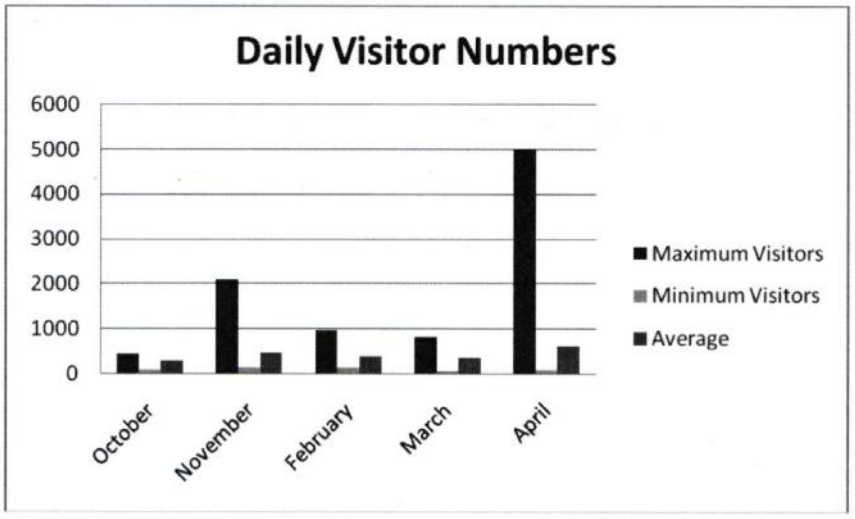
Wind speed ranged between 8.1 and 0 metres a second, with the highest speeds recorded in October 2001 and April 2002. A storm on the 26.04.02 was unrecorded as it was too dangerous to be on site, with portions of the Temple roof actually blown off.



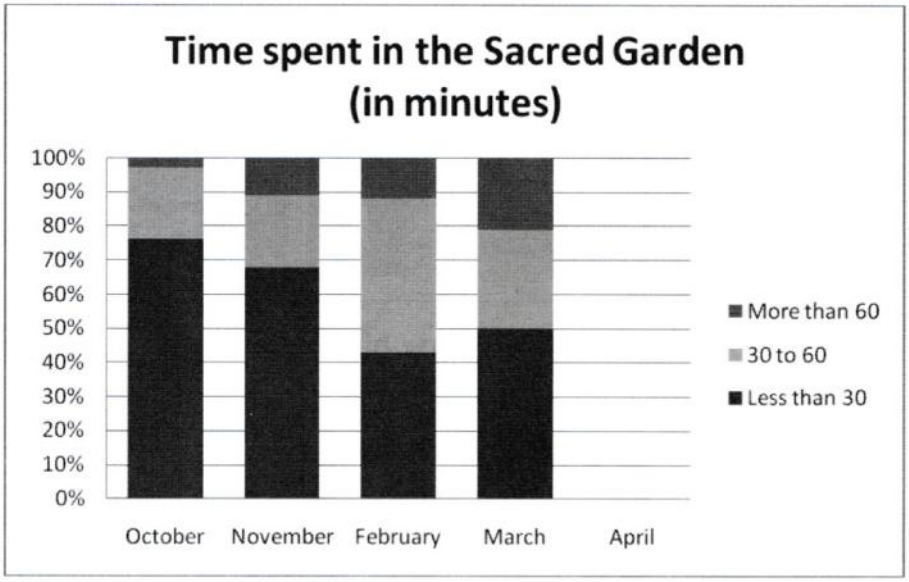
On seven occasions, it was also possible to take temperature and humidity readings within the Marker Stone chamber itself; on 11.09.01, 14.09.01, 22.11.01, 13.02.02, and 25.02.02. These readings are given below.

Date	Time	Temperature	Humidity
11.09.01	10.00	27.3 °C	79%
11.09.01	13.00	27.2 °C	75%
14.09.01	10.30	26.3 °C	98%
14.09.01	13.00	28.0 °C	92%
22.11.01	09.00	21.6 °C	94%
13.02.02	14.45	23.7 °C	68%
25.02.02	08.45	19.4 °C	92%

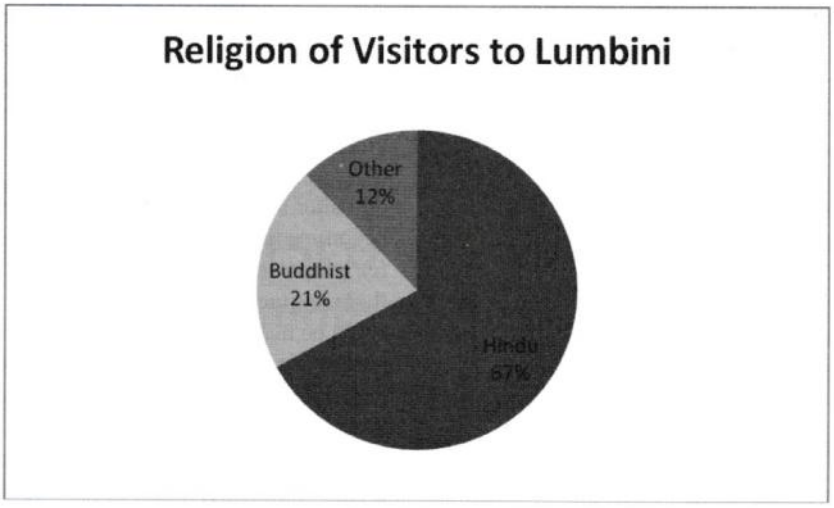
3.2: The Visitor Survey Results Following the recording of visitors at the site, a number of observations and recommendations may be made. Estimated monthly visitor numbers to the Sacred Garden fluctuated between 11300 and 5846 individuals, with a daily maximum count of 5000 and daily minimum of 62.



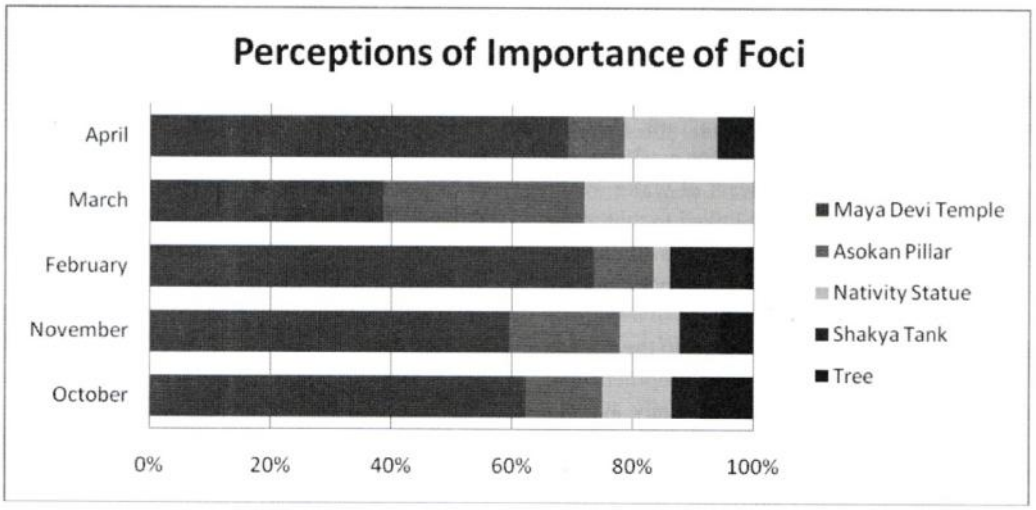
In terms of the amount of time spent on the site, 68% of visitors spent less than 30 minutes at the site. Between 60 and 70% of visitors had visited the site previously, with only between 40 and 30% making their first visit. It was most notable that between 64-81% of visitors did not stay overnight in Lumbini, partially explaining the reason for the low amount of time spent at the site itself by visitors.



Buddhists and Hindus formed the largest identifiable religious affiliation of visitors, with Nepali citizens representing the largest numbers of visitors to the site representing between 49 and 75% - Sri Lankans and Indians formed the next largest groups, although there were clear monthly fluctuations and concentrations.



Whilst the Maya Devi Temple was identified by most visitors (44%) as the most important feature of the site, the Asokan Pillar was judged most important by 15.3%, the temporary Nativity Temple by 11%, the Tree beside the Tank by 2.7%, and the Shakya Tank by 4.3%.



4. Conclusions

The aim of collecting this data was to assist in the continued management and development of the UNESCO World Heritage Site of Lumbini, and to this end several observations and recommendations can be made from this data. Having logged the water levels for eight months at the site, there was clear evidence that the water level within the Maya Devi Temple inspection pit is closely linked to that in the Shakya Tank. There was also clear evidence that substantial fall of rain resulted in the raising of the water level in both the Shakya Tank and the inspection pit. It was notable that rainwater did not drain away from the Temple but, rather, collected in pools on its edges as these areas are lower than the rest of the archaeological site due to archaeological work. This water then drained slowly onto the clay natural below the archaeological deposits. As there are a number of archaeological trenches within the Temple cut down to the natural soil, when the

surrounding soil was saturated these trenches acted in almost the same way as wells and water rose rapidly within them. Once again, this survey did not cover the monsoon season at Lumbini, during which rainfall, water levels and standing water are all far higher.

In order to mitigate this annual flooding, it would be possible for the uneven ground surface in the vicinity of the Temple to be built up and provided with a shallow peripheral drainage channel in order to immediately drain standing water away from the Temple structure and water from the Temple roof structure (Figure 1). Such a proposal would be non-intrusive and there would be no question of a loss of authenticity as a century of archaeological activity at the site has produced the current, artificial and uneven level.

However, if such a proposal was implemented, it might be advisable to cover the current land surface with a geotextile in order to provide a notable separation between archaeological deposits and levelling material. In this way, run-off could be directed into the Shakya Tank and then the level of water within the Marker Stone chamber be regulated by keeping the Shakya Tank at a pre-determined level below the level of the marker stone. As we already know that the level of water in the Temple inspection pit is directly linked to that of the Shakya Tank, by lowering the level in the latter the level in the former and in the Marker Stone chamber would also be lowered.

The impact of visitor numbers to the site can also be considered in all future development and management of the site. Whilst the daily average of 422 represents only 46.8 visitors per hour during a nine hour day, the maximum daily visit count of 5000 for April 2002 represents some 555 visitors an hour. Such numbers, one new visitor every 6 seconds, may overwhelm any protection for the site if capacity numbers are not recognised in advance. Although the Maya Devi Temple was identified as the most significant element of the site by the largest proportion of visitors, it is important to note the importance of the Pillar, Nativity Temple and Tank. Since this logging, further attention has been drawn to the Temple by the reinstatement of the Nativity image, but the pillar has been neither neglected nor overwhelmed as a distinct and separate focus of visitor attention. The Pillar and Temple are now beginning to be provided with clear ritual focus areas for lamps and offerings so as to reduce damage to the monuments themselves. Further visitor control could be made by developing major routes from the entrance gate to circumambulate the Temple and Pillar with a minor loop linking the pond and tree, as is done currently.

Clearly, the Sacred Garden is a major focal point for both pilgrims and tourists, and the number of visitors to the site reflects this. However, if the site is to accommodate these visitors, and more, continued monitoring of environmental conditions and visitor numbers and activity is vital to the ongoing management of this site of outstanding universal value.

5. Acknowledgements

Throughout our stay in Nepal the mission was provided with the generous help of the Government of Nepal, UNESCO's World Heritage Centre and the UNESCO Office, Kathmandu. We would also like to acknowledge the following individuals, without whose assistance the mission would not have been successful. They are, in alphabetical order: Mr. B. Bidari, Mr O.P. Gauchan, Ms H. Gurung, Mr P. Khatri, Mr Y. Kitamura, Mrs R. Pradhan, Mrs S.M. Rana, Mr J.L. Shrestha, Mr O. Shrestha and MS J. Taniguchi. Finally, we must acknowledge the financial support of UNESCO for this work.

6. References

Coningham, R.A.E. & Milou, J.F., 2000. *Reactive Monitoring Mission to Lumbini, Birthplace of Lord Buddha.* Paris; UNESCO.

A Pilot Geophysical and Auger Core Evaluation within the UNESCO World Heritage Site of Lumbini, Nepal

Coningham, R.A.E., Schmidt, A. & Strickland, K.M.S

Abstract

In July and August 2001, a team of archaeologists and archaeological scientists from the UK were invited to carry out a pilot geophysical and auger core evaluation of the core zone of the UNESCO World Heritage Site of Lumbini, the birthplace of Siddatha Gautama Buddha, in collaboration with a team from the Lumbini Development Trust and the Department of Archaeology, Government of Nepal. The evaluations successfully identified the partial extent of the archaeological remains within the Lumbini Sacred Garden, developed a simple projected macro-stratigraphic profile for the site, and successfully identified probable archaeological features in the immediate vicinity of the Maya Devi Temple and on the Lumbini Village Mound to its south-west.

1. Introduction

Having been identified in the nineteenth century as the land of the Buddha's nativity and childhood, Lumbini and its associated sites in the Terai (Figure 1), gained importance for archaeologists and growing numbers of Buddhist pilgrims, but it was not until the visit of U-Thant, the General Secretary of the UN, in 1967 that it reached a modern international status. U-Thant, a devout Buddhist, began a campaign to establish Lumbini as a centre of international Buddhist culture and learning (Figure 2). With the creation of the International Lumbini Development Committee, the campaign achieved notable success with the launching of the Master Plan for Lumbini's development in 1978, designed by the Japanese architect, Professor Kenzo Tange of Tokyo University. The Master Plan is now being realized under the auspices of the Lumbini Development Trust, which was established for that purpose in 1985. The Master Plan is an ambitious project which transforms three square miles of paddy land into "a sculpted landscape to make the teachings of the Lord Buddha accessible to all humanity" and is divided into three linear zones. The first, and most southern, zone is the Sacred Garden, which surrounds the archaeological reserve; the second, or monastic, zone is divided into forty-one plots for places of worship; and the final zone is the residential village for visitors and tourists, separated from the second zone by museum, library and research centre. Although much of the plan exists only on paper only, the Sacred Garden is now demarcated and hotels, monasteries and the research centres steadily rise out of the surrounding forest. In line with other archaeological monuments of outstanding universal value, it was proposed to nominate Lumbini for inscription on the UNESCO World Heritage List, a recommendation which was confirmed in 1997.

The site of Lumbini has seen archaeological investigation for over a century (Rijal 1996), with a number of archaeological excavations carried out on the Maya Devi Temple and its associated structures in the immediate vicinity (Mukherji 1969; Rijal 1979; Mishra 1996; Japan Buddhist Federation 2001). However, the spatial extent of the archaeological remains across the wider Sacred Garden area had never been investigated, hindering the evaluation of the archaeological vulnerability of the site and thus placing archaeological remains at risk from installation of pilgrim and visitor amenities and services, as well as reducing the understanding of the Sacred Garden's archaeological sequence and spatial distribution.

In order to address this, a pilot archaeological evaluation utilising geophysical and auger core survey was initiated by the Government of Nepal, in conjunction with UNESCO. This pilot evaluation aimed to determine the location and vulnerability of archaeological remains within the Sacred Garden, and to begin to assist the national authorities in determining which areas within the Sacred Garden are high, medium and low sensitive archaeological areas, as well as commencing the process of preparing adequate maps and re-identifying the physical perimeters of the archaeological site which did not necessarily relate to the boundaries enclosed within the modern protective fence.

2. Methodology

2.1 The Auger Core Survey: Soil auger coring has long been practised in the Netherlands for buildings up compilation maps of soil types (Steur 1961). Attempts have also been made at conducting close-interval coring of archaeological sites in order to predict detailed internal site structure (Hoffman 1993), however, the best results are when dealing with sites at a macro-level (van Andel & Runnels 1995). This method of survey, in combination with geophysical survey, has also been very successful in identifying the boundaries of the Early Historic city of Anuradhapura, a UNESCO World Heritage Site in Sri Lanka (Coningham 1999).

Using a collapsible 3.5m long Eijkelkamp soil auger for heterogeneous soils, cores were taken along two transects across the centre of the fenced area of the Sacred Garden and out into the surrounding fields. Each 0.2m soil core was recorded for Munsell colour, texture and inclusions. Using the results of these cores, we were able to reconstruct the stratigraphy from these samples and to draw a profile section, allowing us to confirm or refute the presence of subsurface cultural material. Drawbacks of this method include the inability of heads to grind through stone and certain bricks, whilst potential damage to a site or objects is statistically minimal. It is a rapid and cost-effective method of sub-surface investigation. Whilst coring, we found that we could complete a 3.5m deep core in about 3 hours. At the completion of the pilot evaluation, we successfully conducted a core profile north-south across much of the Sacred Garden, a partial east-west profile and an indicative projection of areas of archaeological deposits. These cores have allowed us to build up a simple projected macrostratigraphic profile for the site, which can be tested more fully at a later date.

2.2 The Geophysical Survey: Archaeological geophysics, a non-destructive technique, is now an integral part of non-destructive site assessment in the UK, and has been successfully used in South Asia (Coningham & Schmidt 1997; Schmidt & Coningham 2010). It can record shallow sub-surface features quickly and requires only a small team, making it both time and cost-effective. Within the UK, it is generally used in two ways; firstly, to assist with site management and, secondly, to investigate and assess newly discovered sites. The former involves the large scale survey of the monuments in order to define their extent below the surface. Often the distribution of standing monuments may be very different to that of foundations and other remains which are sub-surface. When such a survey is conducted, it is possible to map the position of unexcavated structures in order to gauge the importance of the various areas of the site. This information should be stored, preferably on a GIS system, and when any site development plans are proposed, such as the construction of paths, drains, pipelines or museums, these areas can be avoided. Similarly, if the relationship between sub-surface monuments is questionable, it is possible to locate suitable areas for research-oriented excavations and evaluations. The geophysical element in site assessment is also designed at allowing archaeologists and conservators to identify the best areas to work.

The objectives of this pilot evaluation were to identify any remains in a sample of survey areas that are related to earlier structures present on the Lumbini Village Mound and within the fenced boundaries of the Sacred Garden. In particular, a set of surveys were conducted as close as possible to the Maya Devi Temple in order to identify any remains in its direct vicinity which might be affected by proposed intrusive building or drainage works. Earth resistance and fluxgate gradiometer surveys were carried out on both sites. The choice of these methods was based on the prevalent use of burnt bricks as building material in Historic and Early Historic times, as evident from earlier surveys in the Terai. Structural brick remains, such as foundations, usually produce distinct magnetic signals and often also form a barrier to electrical current flow, showing as high earth resistance.

A set of geophysical grids were laid out with a size of 10m X 10m. The arrangements of these grids, designed to form a small sample of the entire area of potential archaeological site, is shown in Figure 2.

The survey area was divided into five Sites (Figure 2), the first three within the fenced precinct (north, west and south of the Maya Devi Temple), Sites 4 and 6 on the Village or Police station mound and Site Five to the north of the Mustang Temple. Only parts of these Sites were surveyed for earth resistance (see Figure 2). A co-ordinate system was established for the whole area with an EDM Total Station, with the coordinates centred on the current floor level of then Asokan pillar at location 0m(E), 0m(N), 101m(height). The co-ordinates were aligned North and chosen to coincide exactly with the squared site plan by Professor Kenzo Tange for which a concrete peg was found at position 80m(W), 240m(S). All base lines and most grid corners were recorded with the EDM Total Station.

The survey was undertaken, using a Geoscan Research FM36 fluxgate gradiometer and a Geoscan Research RMl5 earth resistance meter and frame PA5n, along lines parallel to the grid edges, walking west to east and starting in the north-west corner of each grid. The grid size was 10m X 10m, data were recorded every 0,5m along the lines which were 0.5m apart (10m X 10m @0.5m X 0.5m). A twin-probe configuration was used for the earth resistance survey (separation of mobile electrode was 0.5q of remote electrodes approximately 3m). A current of 1mA and a gain of 10 were used. The fluxgate gradiometer was set to a recording of 0.1nT.

Earth resistance data were recorded automatically upon insertion of the electrodes in the ground (medium logging speed). Subsequent lines were surveyed in alternate directions ('zigzag'). Fluxgate gradiometer data were recorded walking with manual or automatic trigger. All lines were walked in the same direction ('parallel'). After completion of each grid, the drift of the equipment was logged at a common reference position and the electronic and mechanical set up of the instrument adjusted. Data were downloaded using *Geoplot* and these data and metadata are used for archiving. Subsequently, grids were matched to each other using the automatic functions of *Contors* or 'Zero Median Grid' in the *Grid* software. Highpass filtering of earth resistance data was tested but did not show any enhanced features so that it was deemed unnecessary and hence no filtered data were used for the interpretation.

Some of the pilot magnetometer surveys contained large ferrous features, such as the water pipe on Site Five, which caused the magnetometers to saturate, resulting in missing readings ('dummies'). These were replaced by estimated values using the 'stitching' function of Grid. The data are displayed as greyscale diagrams, bi-linearly interpolated to 0.25m and affinely transformed according to the recorded co-ordinates of their baselines using Grid. The georeference images were then imported into Arcview, which was also used to generate the georeferenced interpretation diagrams.

3. Results

3.1: Pilot Auger Core Evaluation: A total of 47 points within the Sacred Garden of Lumbini were investigated during the auger survey (Figure 1). At each point, we recorded the surface height in relationship to the Asokan pillar (101m), the depth of the water table in the soil profile, the depth of natural clay in the profile and the presence, or absence, of cultural materials in the profile, such as ceramics, brickbats and charcoal. In order to avoid modern contamination, we only recorded the presence or absence of cultural materials below a depth of 1m. We recorded the following results (all heights / depths measured against surface):

Auger No.	Depth of Water Table	Depth of Natural Clay	Presence of Cultural Materials
1	NA	NA	NA
2	180cm	180cm	Y
3	180cm	>200cm	Y
4	220cm	220cm	Y
5	60cm	80cm	N
6	100cm	120cm	N
7	100cm	120cm	N
8	NA	NA	NA
9	NA	NA	NA
10	80cm	120cm	Y
11	40cm	>80cm	Y
12	80cm	120cm	Y
13	120cm	180cm	Y
14	NA	NA	NA
15	100cm	120cm	Y
16	60cm	140cm	Y
17	>180cm	160cm	Y
18	>240cm	220cm	Y
19	120cm	120cm	Y
20	>100cm	80cm	N
21	>140cm	120cm	N
22	>100cm	80cm	N
23	180cm	220cm	Y
24	>300cm	120cm	Y
25	>180cm	120cm	N
26	>200cm	200cm	N
27	100cm	120cm	N
28	?120cm	100cm	N

29	120cm	120cm	N
30	100cm	160cm	Y
31	60cm	60cm	N
32	>120cm	80cm	N
33	160cm	160cm	Y
34	>160cm	120cm	Y
35	100cm	100cm	Y
36	>200cm	180cm	N
37	>120cm	60cm	N
38	>120cm	60cm	N
39	>240cm	200cm	N
40	100cm	120cm	N
41	>180cm	20cm	N
42	>160cm	120cm	N
43	>320cm	260cm	N
44	20cm	>220cm	N
45	60cm	80cm	Y
46	280cm	>320cm	Y
47	280cm	280cm	N

As is clear from the two accompanying plans of the Lumbini Sacred Garden, there are three very distinct clusters of archaeological deposits within the circular levee. The first is a cluster of deposits focusing on the Asokan pillar and Maya Devi Temple. It is notable that this cluster extends outside the modern fenced enclosure on all sides. The deposits thus measure an overall extent of at least 180m east to west and at least 240m north to south. Whilst some of this material may represent erosional wash, the size of a number of brick and ceramic fragments suggest that additional structures lie well outside the modern fenced enclosure.

A second, distinct cluster was found to the south-east of the Maya Devi Temple compound and north of the Lumbini Development Trust archaeological offices. This cluster appears quite separate from the Temple deposit and appears related to the brick-lined well close to the eastern access road. The third cluster of archaeological deposits was found on the Lumbini Village, or Police Station, Mound to the south-west of the Maya Devi Temple. A distinct cluster, it further supports the findings of the geophysical survey in this vicinity. The mound appears to be formed by a natural raised feature capped with subsequent human occupation. The two transects also provide useful information concerning the depth of natural virgin soil in the vicinity of the site and its clusters of archaeological deposits. The east-west transect ran from 125m east to 100m west and comprised data from six auger cores. The profile of natural virgin soil suggests that the Maya Devi complex was constructed on the surface of a natural rise of clay surrounded by lower, presumably annually inundated land. This rise or mound appears to stand at least two metres above the surrounding area. The north-south transect ran from 400m north to 250m south and provides an almost complete profile through the Sacred Garden. The surface profile confirms that the Maya Devi Temple complex stands on the highest point but is clearly defined by what may be two deep gullies or cuts into the natural virgin clay. It is possible that these features represent either natural or human features, the former as a silted water course, and the latter as a tank.

3.2: Pilot Geophysical Survey Evaluation: The following figures present overviews of the geophysical data in their geographic location and their interpretation. Identified features are labelled according to their site number, their geophysical origin (m - magnetometer data; r - earth resistance data) and a running numeric label (e.g. '2m3' is the magnetometer feature 3 of Site Two). Figures 14 to 19 show the data plots individually.

Within the fenced compound (Sites One, Two & Three), anomalies 1m1 and 1r1 are clearly identified as a water pipe with a strong magnetic and low resistance signal. While the latter is unusual, it can be attributed to the shallow burial depth. There is indication (1m7 and 1r2) that part of this pipe continues straight on towards the northwest. An even more prominent water pipe with typical checkerboard pattern in the magnetometer data is visible in the west of Site One (1m2) running south through Site Two then turning east to leave the survey area just north of the Shakya Tank. Other modem features include anomalies 1m3, 1m4 (identical with 1r8) and 1m5 which are caused by park benches. Magnetic anomaly 2m16 is due to an iron sign. Throughout the site, paths are laid which produce high/low patterned anomalies in the magnetometer data indicating a composite of burnt material, possibly brick (1m6, 2m17, 3m25 and 3m26). The magnetometer survey was not able to resolve features very close to the Maya Devi Temple as its tin roof is supported by steel cables that produce overwhelmingly strong signals (1m21). Throughout the site, many small dipolar magnetic anomalies were identified which are most likely attributable to near-surface ferrous litter.

On Site One, several anomalies were identified that are probably caused by archaeological features. In the earth resistance data, a pronounced

step is marked by a low resistance feature running east-east across the site (1r11). To its south, several areas of amorphous shapes show very high earth resistance (1r12 to 1r16). They are truncated in the west by a modern flowerbed. As can be seen in the comparison with Figure 7, the two linear negative magnetic anomalies 1m11 and 1m12 run in the same alignment. It is speculated whether this areas is formed by demolition debris, which was retained behind at least one wall (1r11), which has subsequently been removed.

Whether the shape of the associated high resistance anomalies has any resemblance of the original building outline cannot be determined. It is assumed that the buildings were made of brick, which would explain the relatively high 'noise' level in the magnetometer data. Towards the north end of Site One, a string of confined high resistance anomalies is found (1r3 to 1r7, 11-9, 1r10). This alignment would be compatible with a row of man-made features but other interpretations are also possible. Area lm13 has an unusually quiet magnetic appearance but three weakly magnetic anomalies are also visible in this area (lm8 to 1m10), possibly related to buried structures. Anomaly 1m10 seems to continue along the line of the former wall (1r11). Just to the north of the Maya Devi Temple, within the area unsuitable for magnetometer survey (1m21) at least two high resistance anomalies were identified (1r19 and 1r17); they are most likely associated with small stupas or buildings related to the Temple.

On Site Two, magnetic anomalies are divided in to an area of very 'noisy' appearance (2m20) and areas downslope with much more homogeneous readings (1m12, 2m15 and 3m23). It is assumed that the varied readings are caused by brick rubble, further proof of the occupational history of the site. Just north of 2m20, the magnetic noise seems reduced, possibly due to the removal of original topsoil during earlier excavations west of the Shakya Tank. Earth resistance results show high and concentrated values to the west and over the bend of the water pipe. It is possible that they were caused by spoil heaps or other accumulations of rubble material.

Few features were identified on Site Three but again a coincidence of high resistance readings (3r33, 3r34) with areas of 'noisy' magnetic data (south end of 2m20) and low resistance readings (3r31, 3r32) in areas of 'quiet' magnetometer data (3m23) can be seen. This observation is compatible with brick rubble forming large parts of the site but having defined boundaries. Anomaly 3m29 is most likely of ferrous origin. Some more confined weakly magnetic anomalies are visible (3m24, 3m27, 3m28, 3m30) which could be related to individual features. Unfortunately, the Magnetometer survey to the north of the Mustang Temple (Site Five) only showed the distinct signature of a ferrous pipe (5m1). However, the survey of the Village or Police Station mound was divided into two parts: east of the dividing fence (Site Four) and west of the fence (Site Six). Apart from four large modern ferrous anomalies (4m4 to 4m5 and 4m7), the most prominent feature in the magnetometer data of Site Four are two paths joining at a T- junction (4m1 and 4m2).

The magnetic signal has a distinct noisy pattern, which indicates a makeup of brick rubble. While the north-south trending path (4ml) also shows a high resistance anomaly (4rl), the other part of the path does not. It is possible that the resistance anomaly of the former part is particularly enhanced through erosion, which is apparent in some areas. 4r4 and 4r5 are current footpaths across the site. Overall, the magnetic background noise on this site is markedly reduced and it is safe to assume that only very little brick rubble (if any) is present. Some negative noise is apparent in 4m11, which coincides with the distinct low resistance area 4r3. Why this appears so sharply bounded to the north-east is unclear. A number of small high resistance anomalies are scattered across the site (e.g. 4r7 to 4r11 and 4r16 to 4r19) which could be related to tree roots, extracting water from the soil.

Due to the low background noise level, some weak but distinctive magnetic anomalies can be identified. In the north-west of the site, a cluster of curvilinear magnetic anomalies is visible. Some appear to be positive (4m11, 4m14), some negative (4m12, 4m13). However, due to the small size and limited strength of these anomalies, the attribution to positive or negative anomalies is difficult. These anomalies seem to form semicircular enclosures and might be associated with more ephemeral structures of a small settlement.

Traces of these weak structures continue in a more linear way into Site Six (6m1 to 6m3, 6m5). The modern Police Station on the site is probably responsible for the enhanced magnetic background noise, which makes the detection of the weak features difficult. The linear anomalies 6m7 and 6m9 may nevertheless be indicative of underlying structures. Area 6m11 has a distinctly lower noise level.

4. Conclusions

The pilot auger evaluation identified clear evidence of subsurface archaeological deposits in the immediate vicinity of the Maya Devi Temple, as well as outside the fenced enclosure surrounding the Maya Devi Temple complex. It was strongly recommended that these distributions of archaeological sensitivity were preserved 'in situ' and were not damaged by subsequent development.

The pilot geophysical evaluations were also able to differentiate different levels of occupation in the investigated area. High magnetic background noise levels around the Maya Devi Temple seem to indicate demolition debris of earlier brick buildings. This confirms the continued archaeological use of the site. Its tell mound shape (see Figure 1) is therefore probably enhanced by layers of occupation debris. This rubble spread is sharply divided from areas of low magnetic noise. Close to the Temple itself, some structural anomalies were identified which merit further evaluation. On the Lumbini Village, or Police Station, Mound, much reduced background noise allowed the detection of weak curvilinear features, which are most likely, associated with former settlement.

The pilot geophysical findings therefore confirm the rich archaeological past of the site. Although the top layer, which is accessible to geophysical survey, seems to consist mainly of brick rubble, it is feasible that deeper structures still exist. The confined shapes of some of the rubble related anomalies (e.g. north of the Maya Devi Temple, 1r12 to 1r16) could be indicative of the underlying features.

In addition to these archaeological findings, the pilots demonstrated the importance of a combined analysis of magnetometer and earth resistance data. Their evaluation allowed the identification of brick rubble spread. Presence or absence of noise in magnetometer data can be a crucial indicator of past human occupation.

Finally, in view of the clear success of this fieldwork, it is recommended that these pilot evaluations are followed up by a more intensive campaign of combined geophysical and augur survey with results confirmed by limited evaluative excavations to clarify the date and character of the archaeological remains identified.

5. Acknowledgements

Throughout our stay in Nepal the mission was provided with the generous help of the Government of Nepal, UNESCO's World Heritage Centre and the UNESCO Office, Kathmandu. We would also like to acknowledge the following individuals, without whose assistance the mission would not have been successful. They are, in alphabetical order: Mr. B. Bidari, Mr O.P. Gauchan, MS H. Gurung, Mr P. Khatri, Mr Y. Kitamura, Mrs R. Pradhan, Mrs S.M. Rana, Mr J.L. Shrestha, Mr O. Shrestha and MS J. Taniguchi. Finally, we must acknowledge the financial support of UNESCO for this work.

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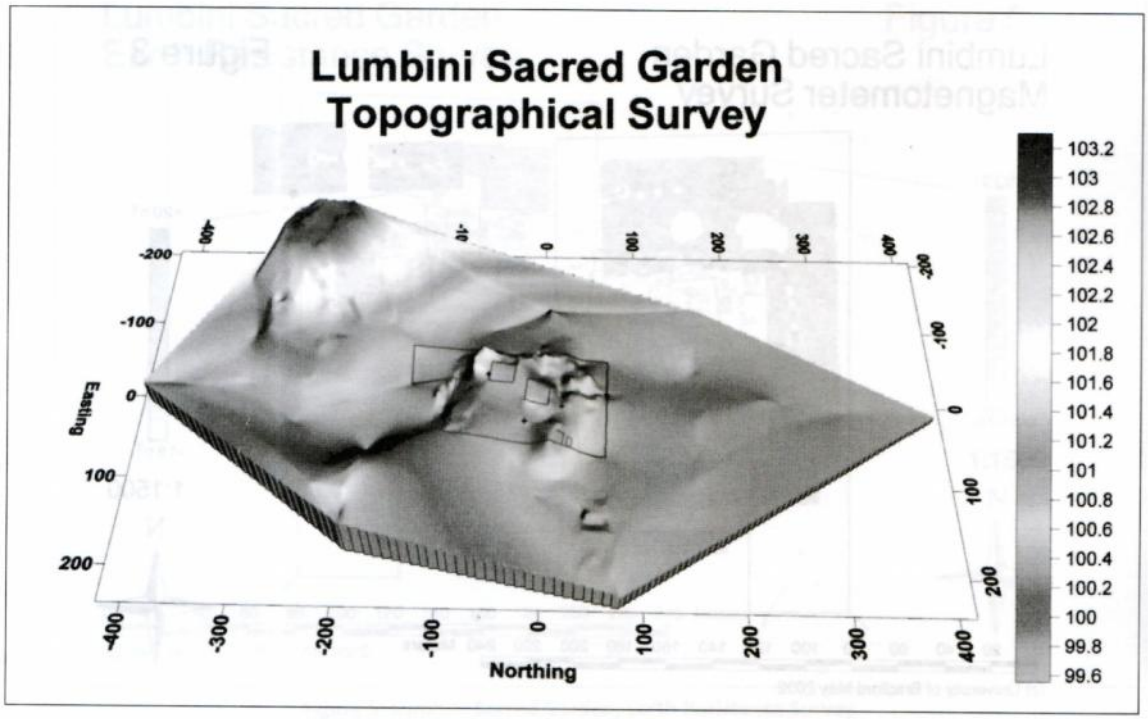


Figure 1: Lumbini Sacred Garden Topographical Survey

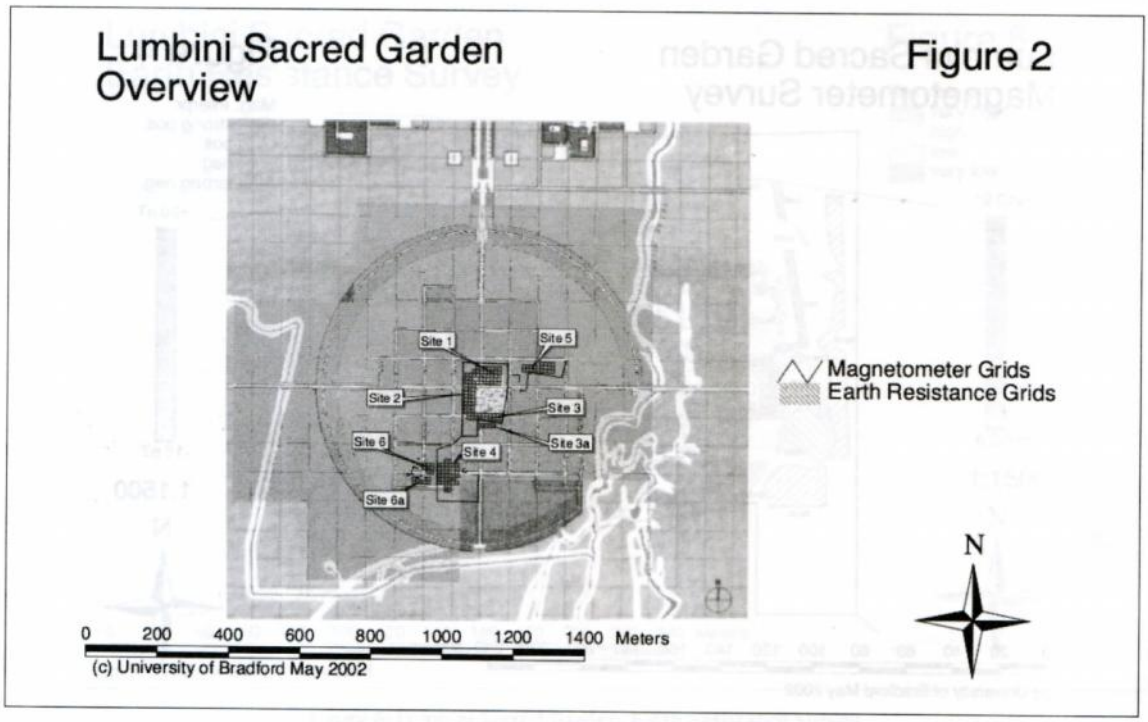


Figure 2: Lumbini Sacred Garden Overview

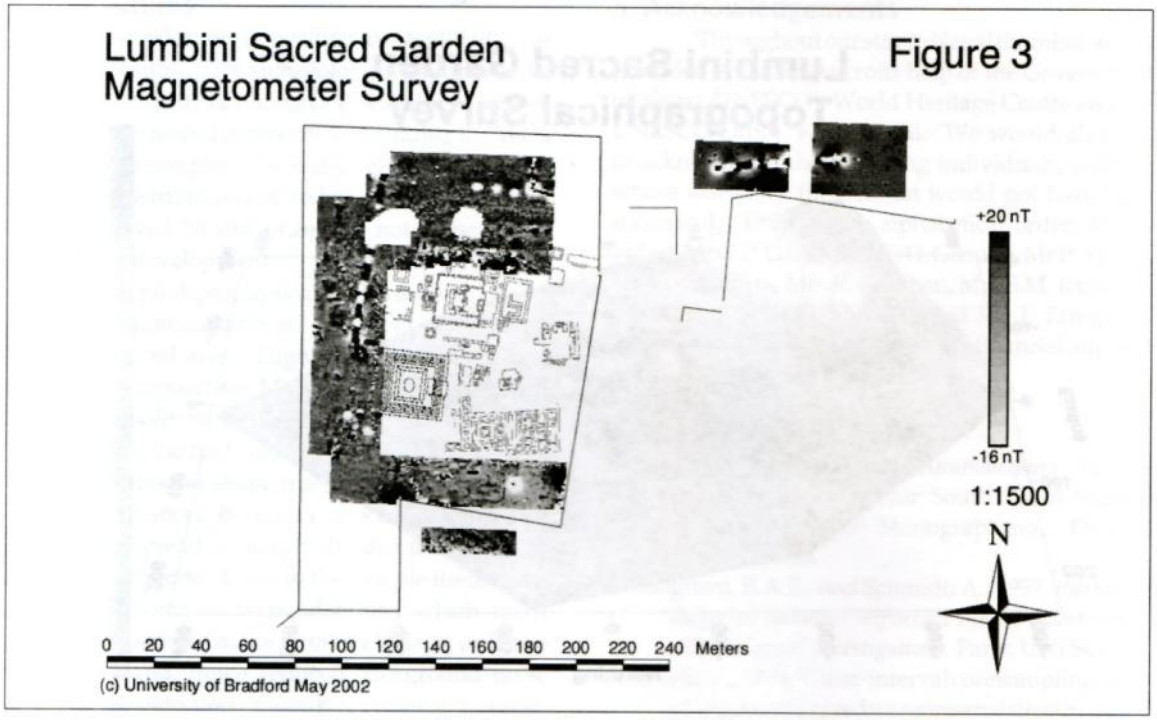


Figure 3: Lumbini Sacred Garden, Magnetometer Survey

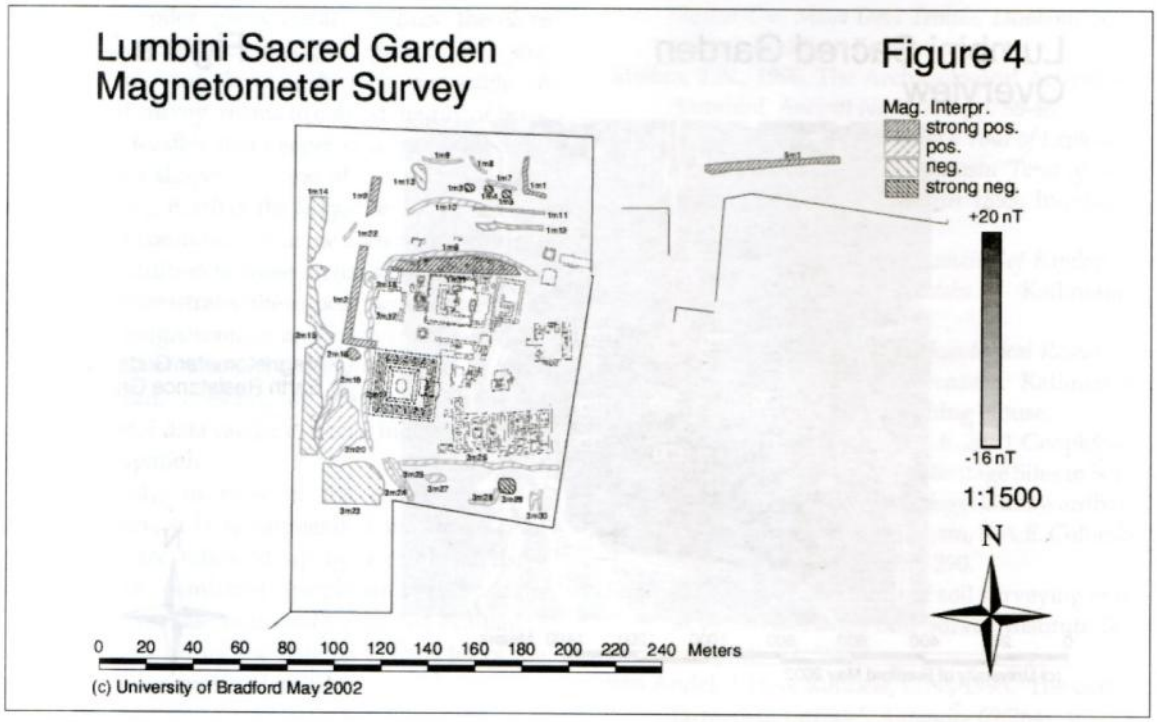


Figure 4: Lumbini Sacred Garden, Magnetometer Survey

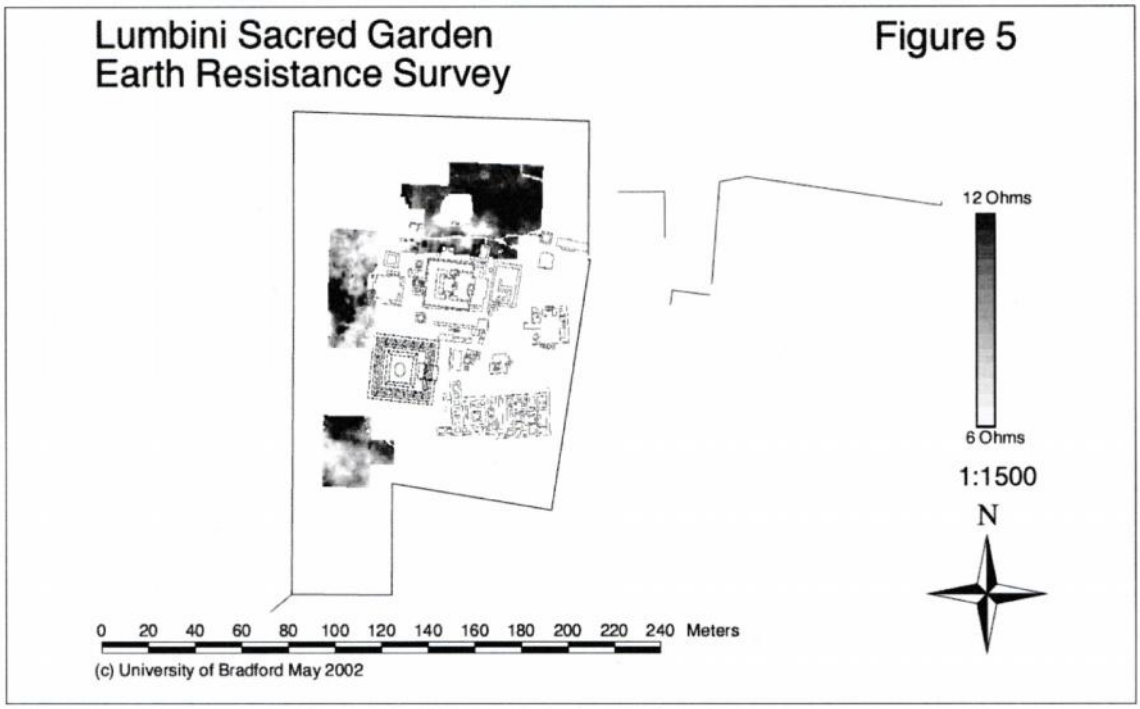


Figure 5: Lumbini Sacred Garden, Earth Resistance Survey

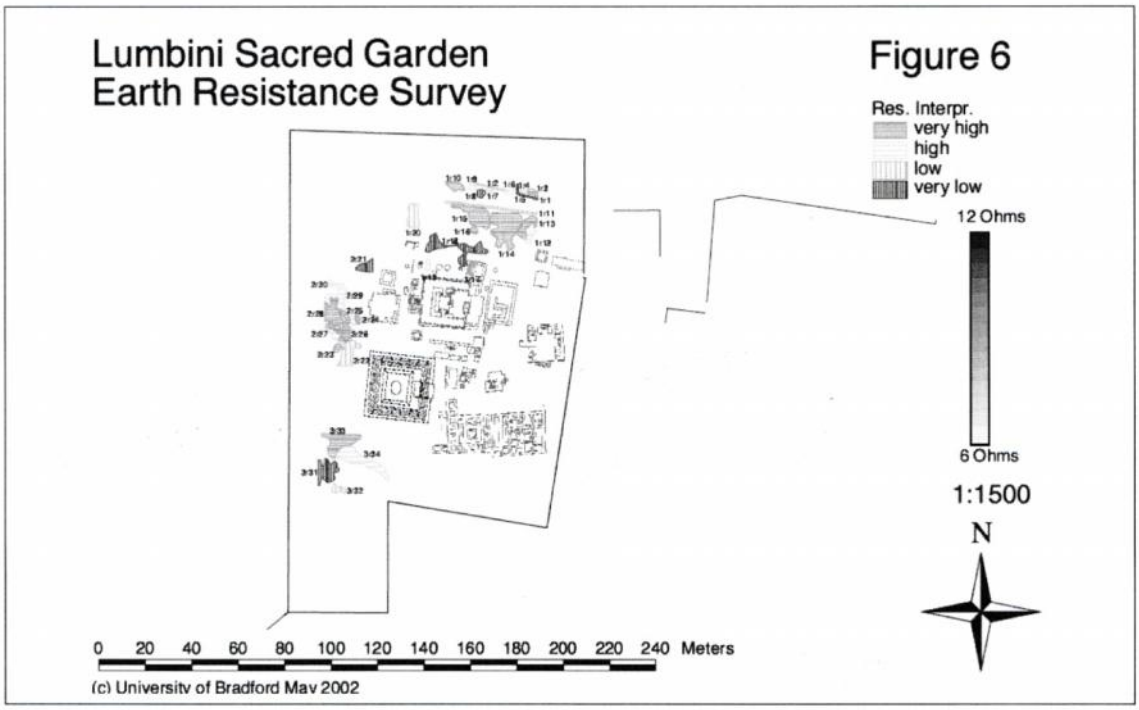


Figure 6: Lumbini Sacred Garden, Earth Resistance Survey

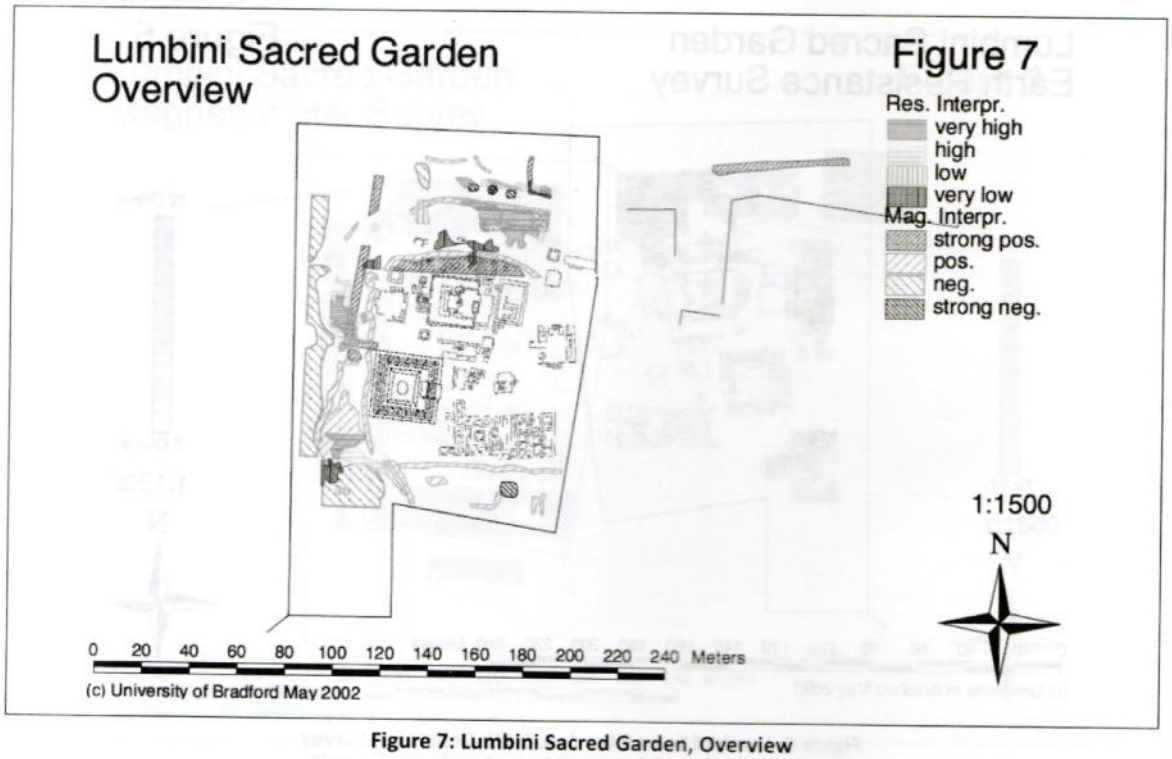


Figure 7: Lumbini Sacred Garden, Overview

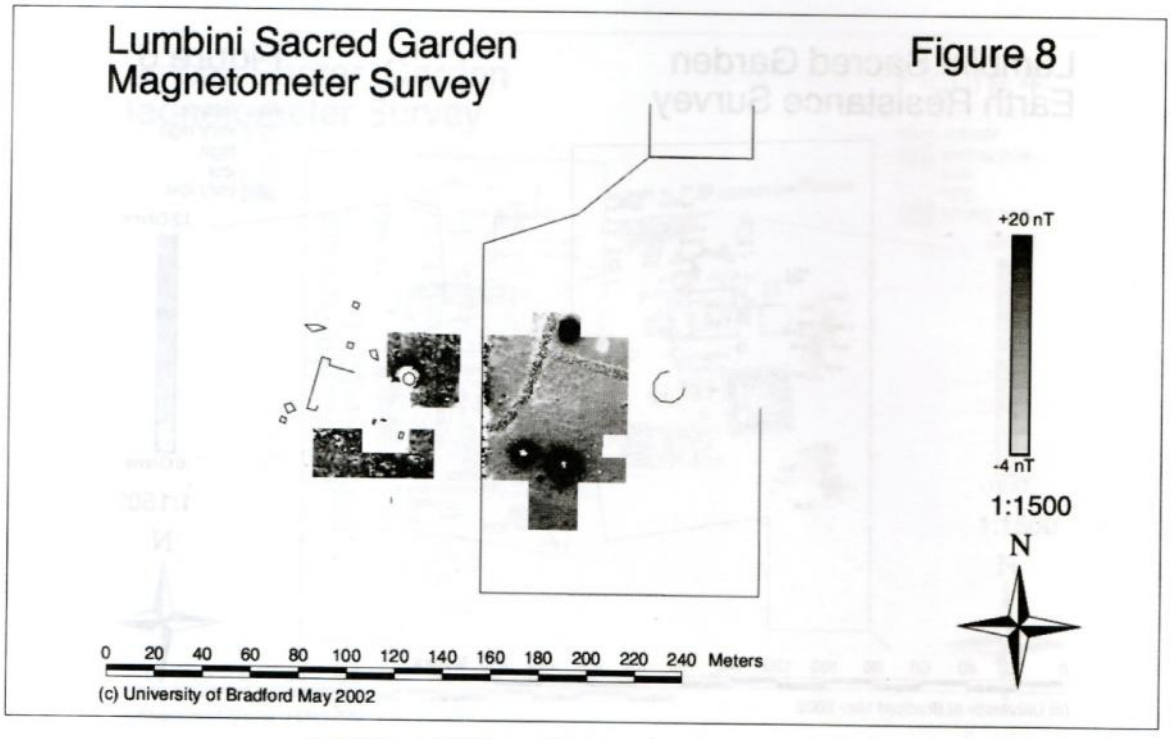


Figure 8: Lumbini Sacred Garden, Magnetometer Survey

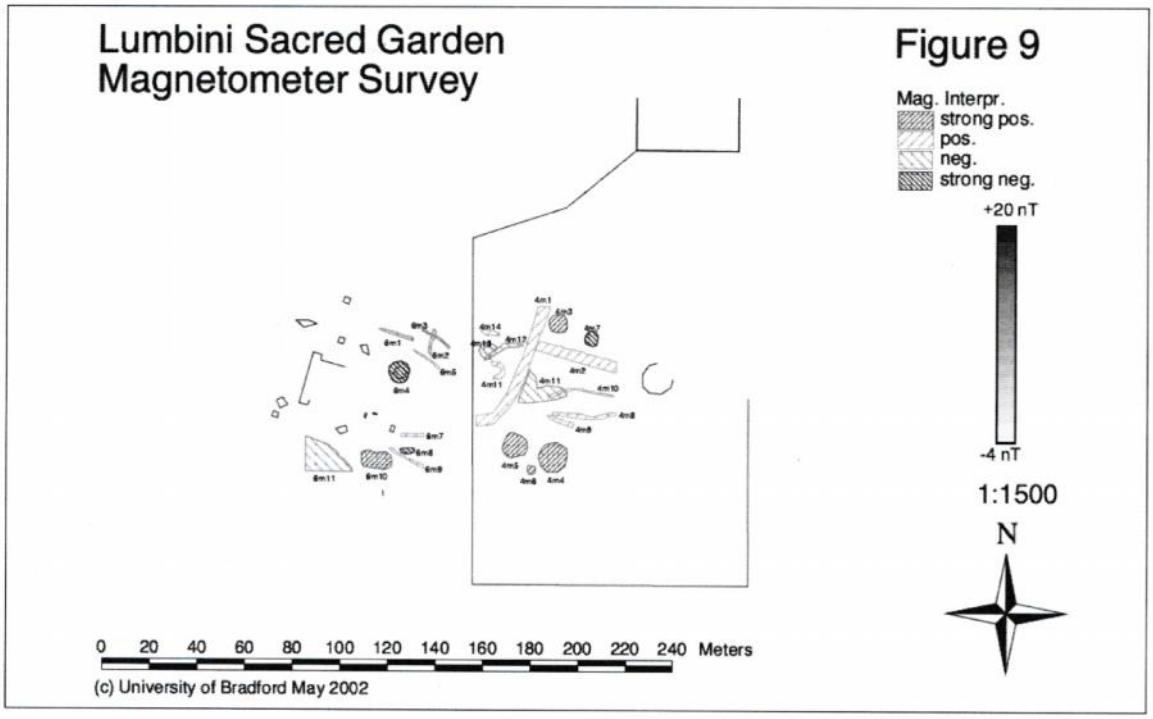
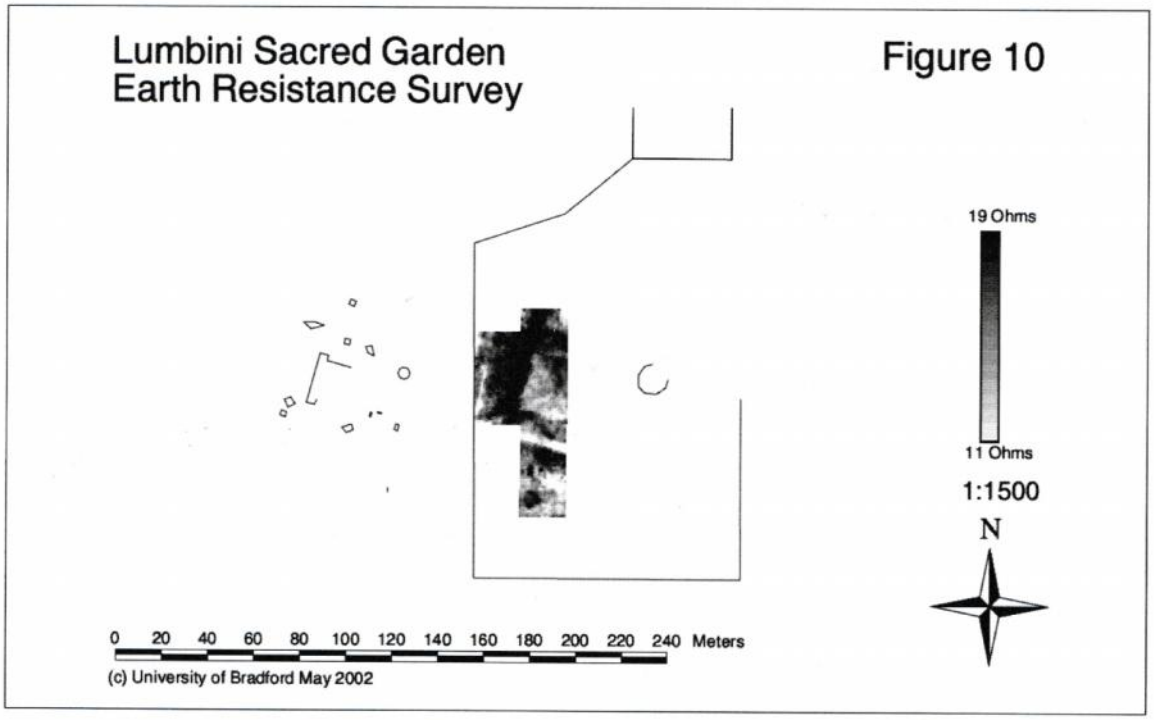


Figure 9: Lumbini Sacred Garden, Magnetometer Survey



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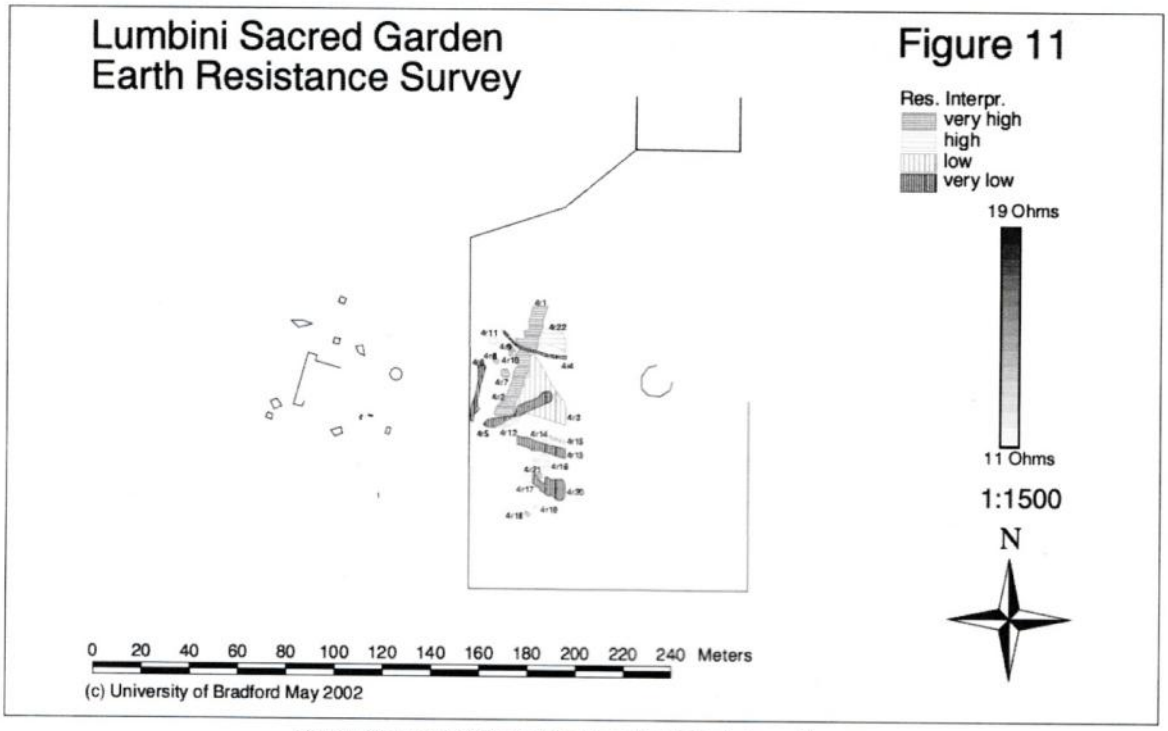

Figure 11: Lumbini Sacred Garden, Earth Resistance Survey

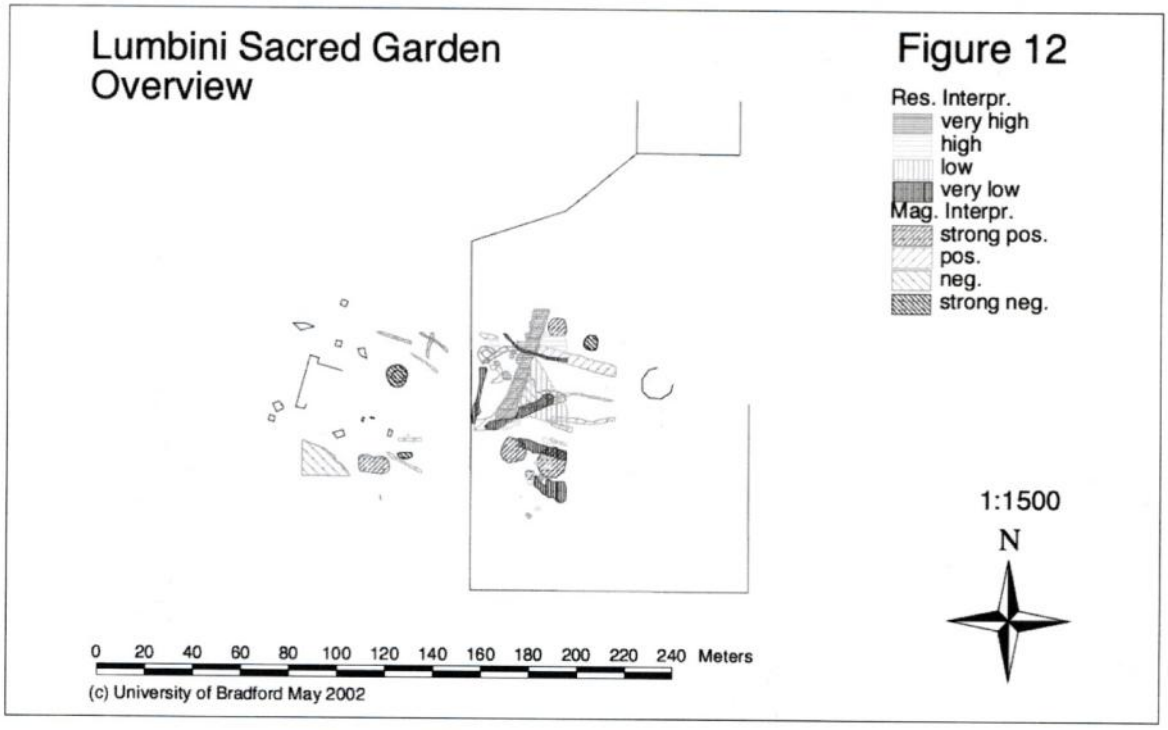

Figure 12: Lumbini Sacred Garden, Geophysics Overview

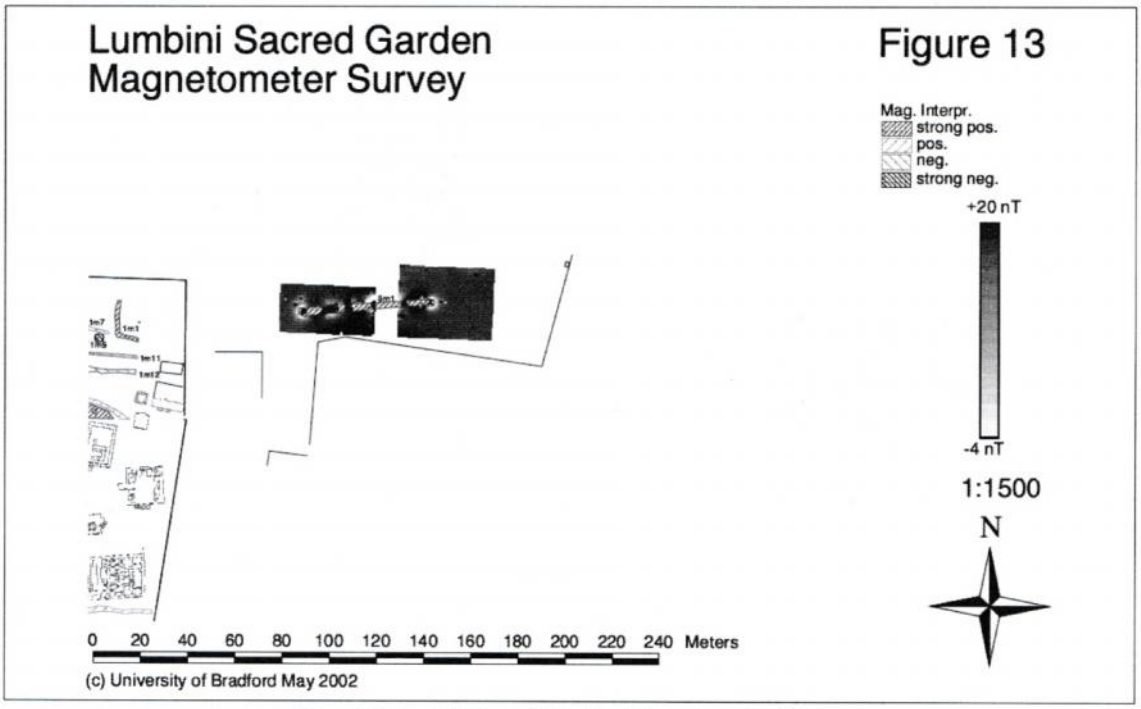

Figure 13: Lumbini Sacred Garden, Magnetometer Survey

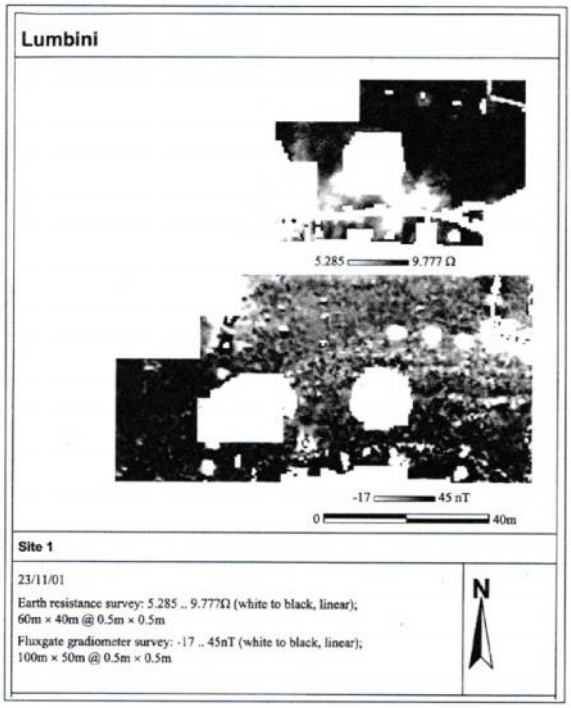

Figure 14: Lumbini Sacred Garden, Site 1 Geophysics

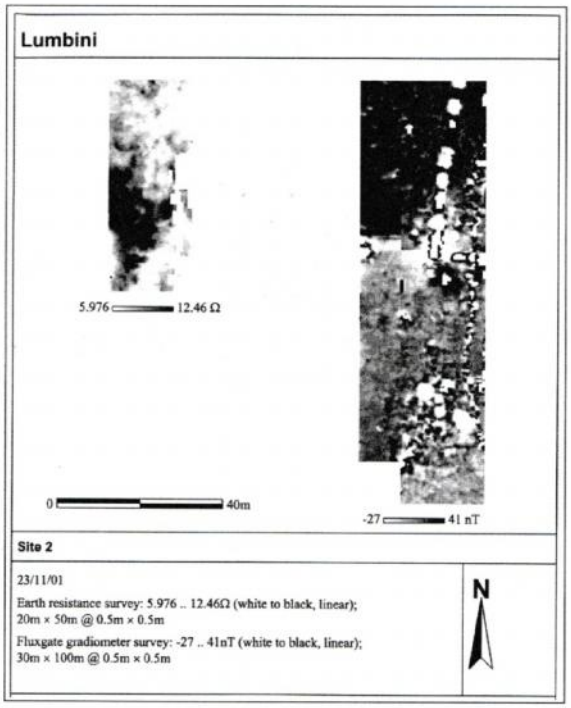

Figure 15: Lumbini Sacred Garden, Site 2 Geophysics

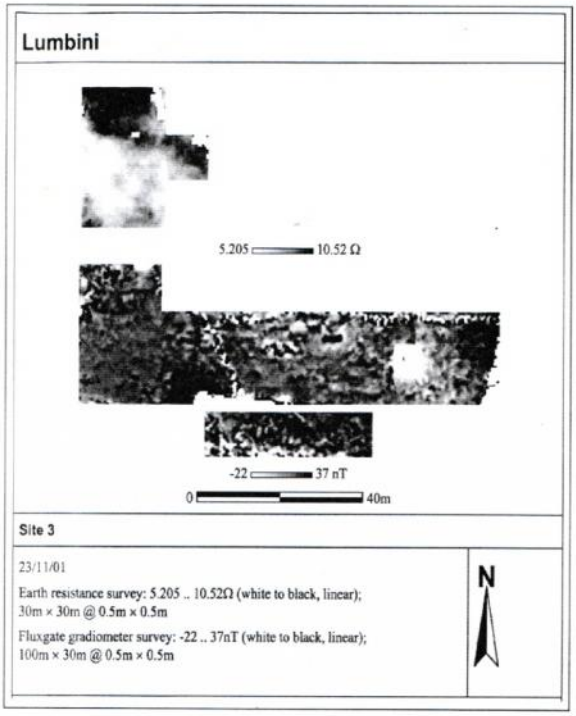

Figure 16: Lumbini Sacred Garden, Site 3 Geophysics

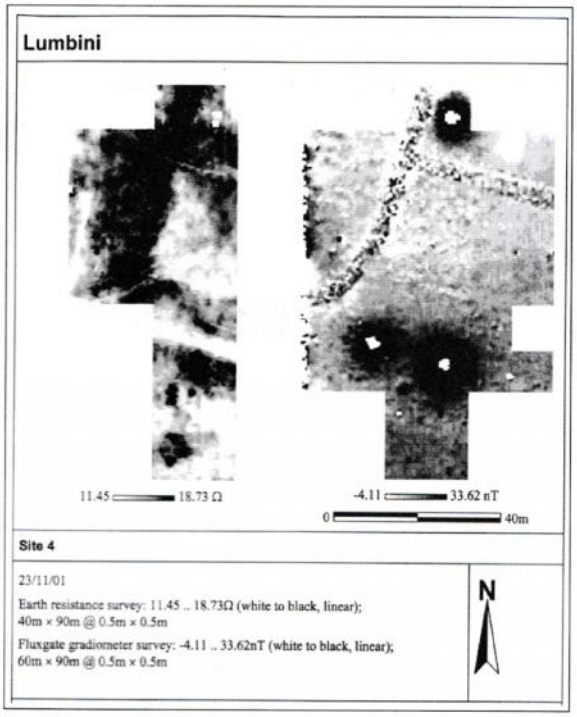

Figure 17: Lumbini Sacred Garden, Site 4 Geophysics

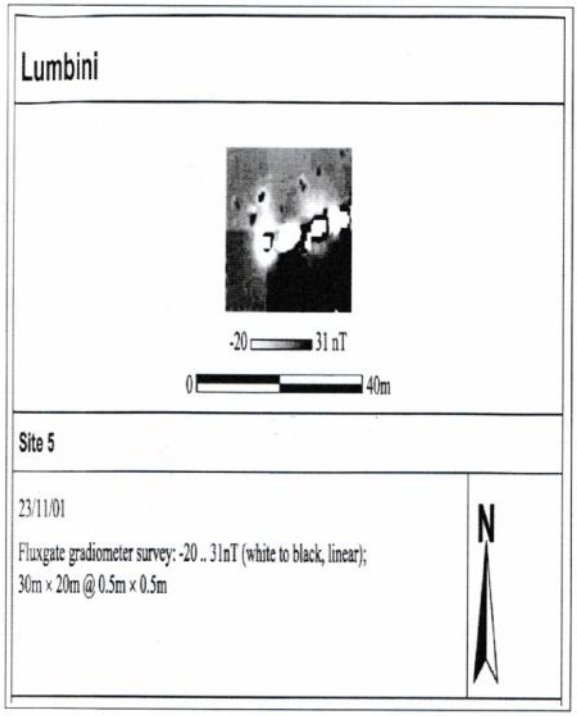

Figure 18: Lumbini Sacred Garden, Site 5 Geophysics

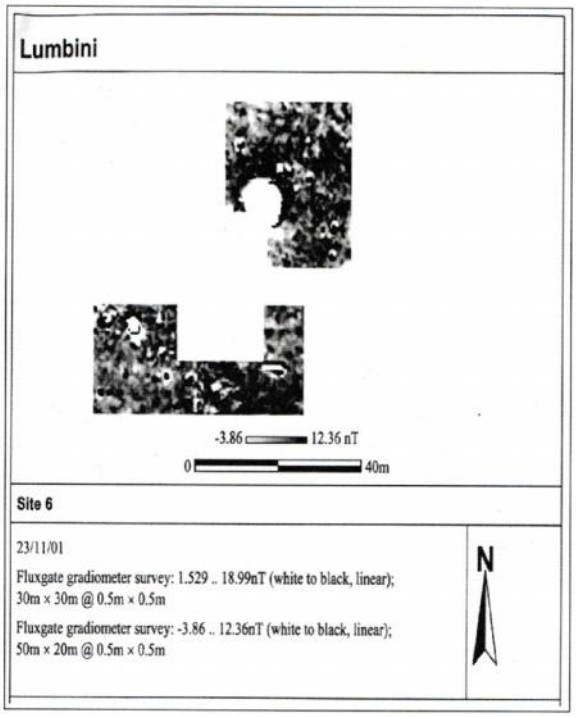

Figure 19: Lumbini Sacred Garden, Site 6 Geophysics

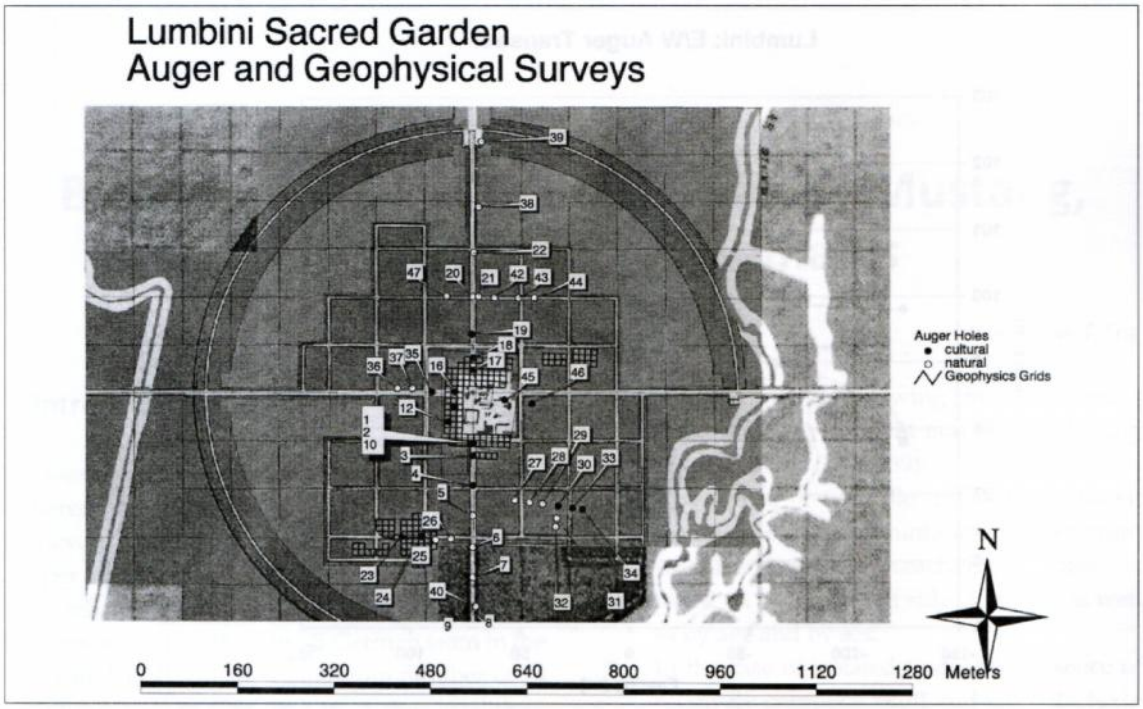

Figure 20: Lumbini Sacred Garden, Auger and Geophysical Surveys

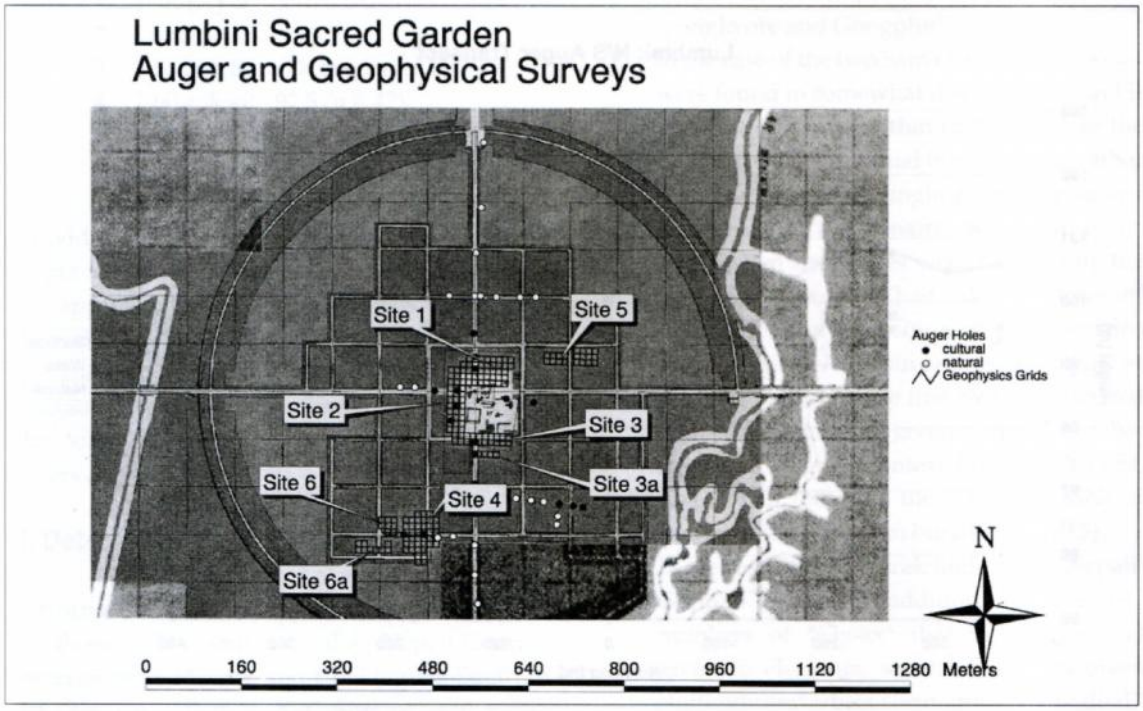

Figure 21: Lumbini Sacred Garden, Auger and Geophysical Surveys

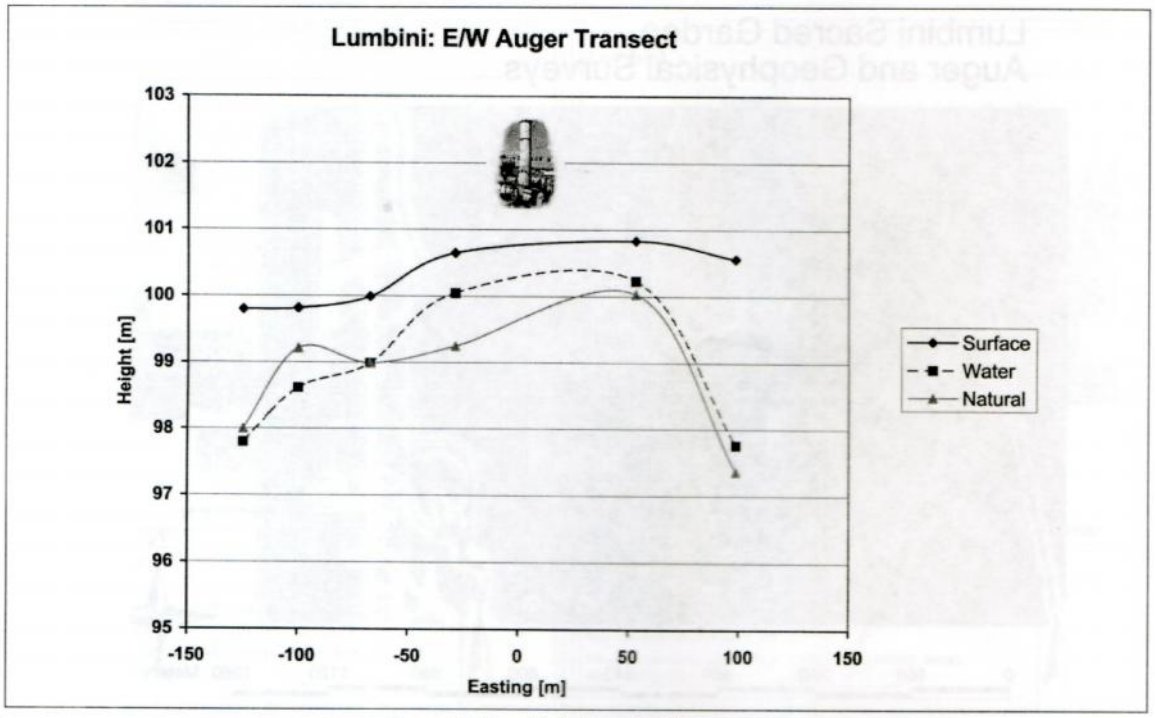

Figure 22: Lumbini, Auger E/W Transect

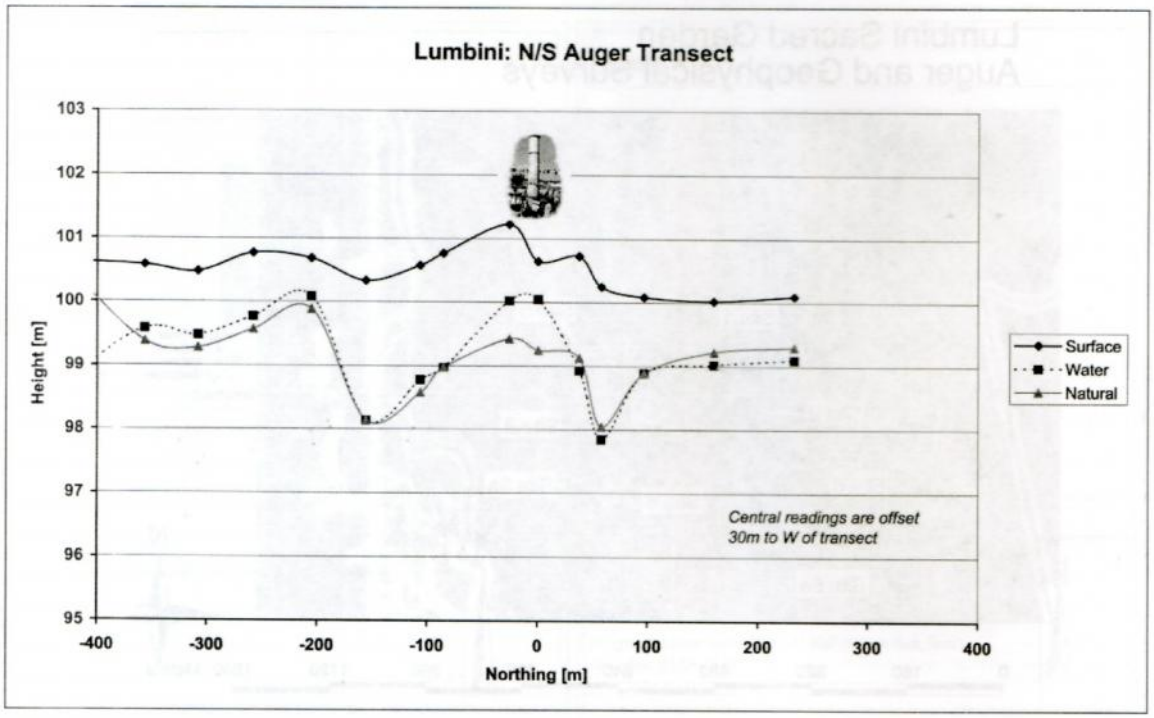

Figure 23: Lumbini, Auger N/S Transect

Bioarchaeological Report of Upper Mustang, Nepal 2010 Human Remains

Jacqueline T. Eng

I. Introduction

During the summer 2010 season in Nepal, ancient human remains were observed in several different contexts: 1) *in situ* in Upper Mustang; 2) removed from *in situ* context, but still located in Upper Mustang; and 3) curated in the Department of Archaeology (DoA) in Kathmandu, having been excavated by the Nepali-German team in the early-mid 1990s. In all, a minimum number of 74 individuals were observed from five localities/ sites:

1. **Jyongkyore North** (n = 1)
2. **Gongphu** (n = 3)
3. The two **Sam Dzong** caves (n = 27)
4. **Mebrak site 92.5** (n = 42)
5. **Chokhopani-South site 93.1** (n = 1)

The remains of a minimum of thirty one individuals were observed by our team in the Upper Mustang region (sites 1-3), and the remains of approximately 43 individuals originally excavated by the Nepali-German team (sites 4-5, curate at the DOA). The following divides discussion of the remains based on context and chronological sequence in which they were observed.

II. Determining Demographic Information

When the primary skeletal analysis was performed by myself (Jacqueline Eng) as opposed to those who analyzed the Nepali-German material from Mebrak and Chokhopani-South in the 199s (e.g., Alt, et al. 2003; Simons, et al. 1998), the minimum number of individuals (MNI) was determined in the following manner having separated bones by element and side, following White and Folkens (2005:339):

1. In the case of multiple individuals present from a given context, minimum number count was determined within each element category, based on right and left side elements, as well as by age and by sex.
2. In the case of isolated finds, the presence of relatively complete skull and any attached/ corresponding axial elements that articulated well with it (especially in the sites of Jyongkyore and Gongphu).
3. In the case of the two Sam Dzong caves, bones were found in somewhat discrete piles, and it was assumed that within each pile were the remains of an individual burial or two, rather than complete commingling and haphazard scattering of all remains within a given cave. When these piles were lowered by the climbing team, who had taken sketches of the relative burial position of these remains I sorted the MNI within each discrete pile, as described above in the first two steps, so that each individual was given a burial number from that original context (e.g., UM2010.5a, UM2010.5b indicates there was an MNI of two individuals within burial UM2010.5).
4. In the case of the Mebrak finds by the Nepali-German team, in addition to inventory numbers of "63x-xx" that their team had given to elements, several had been given "Individuum" labels, German for "individual," presumably because these were elements

from discrete burials. They range in number of Individuum 1 to Individuum 28, yet four individual numbers are missing within that range: Individuum 12, 13, 17 and 24. Note also that several had questions marks next to the labeled numbers, (e.g., "Ind. 5a?" and "Ind.9?"), suggesting that the original observers were unsure of association between elements and individual burial. I determined MNI based on the original inventory labels given them, as well as how relatively complete the remains were. Most of the bones present were either skulls and/or long bones, which are usually better preserved than smaller elements. So if they had given a single isolated femur its own number (e.g., 633-53), I counted that as a single individual, assuming that the excavators had chosen this largest elements as representative of the whole individual (if the skull was not also preserved). Other isolated remains, such as fragmentary loose teeth were not counted within the MNI.

Determining age and sex followed recommendations outlined in Buikstra and Ubelaker (1994), including the examination of dental development and epiphsyseal closure for determining the age of subadults, and cranial and pelvic morphology in the determination of age and sex for adults. Ages were broken into eight age categories, from Infant (0-2 years), Child (3-6 years), Juvenle (7-12 years), Adolescent (13-19 years), Young Adult (YA, 20-34 years, Middle Adults (MA, 35-50 years), Old Adult (OA, 50+ years), and Adult of unknown age (20+ years). When the individual lacked diagnostic features to determine age and/or sex, the designation of broader categories such as adult vs. subadult, or individual of unknown sex was noted.

For determination of carbon dating, migration patterns and population affinity, samples were taken for strontium isotopic analysis and ancient DNA analysis (to be performed in laboratories in the United States). The preferred sample were molars or other teeth in their absence, but on a few occasions there were no teeth available, so remaining desiccated soft tissue were removed. These samples were removed after dental and skeletal analysis and are reported elsewhere. Also, as part of Dr. Christopher Schmidt's Dental Microwear Project, Jacqueline Eng also took molds of intact molars (most of which were used for later used in the analysis described above). The results of these finds in dental microwear structure, and the implication for diet and use-wear pattern of teeth, will be reported at a later date.

III. Burial descriptions

Burials from the Upper Mustang (UM) region, both those found originally in 2008 (Jyongkyore and Gongphu) or this past season in 2010 in the Sam Dzong caves were given the label UM 2010, with individual burial numbers following, numbered in sequence of when analyzed by myself (Jacqueline Eng). Note, all of the caves explored required technical expertise to access (rappelling from above), which suggest they had were undisturbed by modern humans until explored by our team, although animals could have caused taphonomic damage. Below are the descriptions, beginning with the 2008 materials, which are described in detail here, while the data from Sam Dzong and Mebrak, which contain many more individuals, are represented by summary information, with an appendix of individual burial description in another document.

A. Summary information of 2008 material:

- Four burials examined (some parts *in situ* and others stored elsewhere e.g., Choesar village for Jyongkyore skull and DoA for Gongphu skulls)
  - o Jyongkyore (UM2010.1): Middle aged female skull and postcranial axial skeleton
  - o Gongphu (UM2010.2): Adult male skull and postcranial axial skeleton
  - o Gongphu (UM2010.3): Older adult male skull and postcranial axial skeleton
  - o Gongphu (UM2010.4): Adult female skull and postcranial axial skeleton

UM2010.1 - **Jyongkyore** (recovered/examined July 29, 2010)

These remains of a middle aged adult female, located in the Jyongkyore North Cave in Choesar, were originally discovered in 2008, with dating of single molar found yielding a date about 16th c. AD. Pictures from 2008 indicate that the skull had been not articulated with the rest of the axial skeleton; the latter was left *in situ*, while the cranium, which included the attached cervical (C)1 to C5, had been brought to Choesar village where I later examined the them. Cranial suture closure was used to estimate an age in the mid-thirties at time of death. The cranium had a slight band of depression ust posterior to the coronal suture that created a thicker ridge of bone across that suture, indicating habitual weight placed on that area, probably similar to the still current practice of load bearing of a *dolpo* basket with the use of the a strap across the head. The maxilla only had sis teeth present, with antemortem toothloss of six teeth: left lateral incisor (I2) to the first molar (M1) and right fourth premolar and M1. There was a cavity on the second right molar, which had been used for biochemical analysis in 2008. There was no mandible.

The axial skeleton left *in situ* included C6 down to the pelvis, with ribs noticeably broken off (perhaps postmortem) close to the transverse processes of the thoracic vertebrae, around the angle portion of ribs. What remained attached to the thoracic vertebrae where all 12 rib heads on the left, and the heads of right ribs 4-12. Pink pigmentation had been applied postmortem on the skeletonized remans, especially on posterior left side of thoracic area. The pigment had apparently been applied after the ribs were broken/snapped since some pigment is inside rib shafts. Furthermore, there is a significant "primary" curvature of the spine that is C-shaped with continuous anterior concavity for C6 to the lumbar vertebrae, indicating a severely bent back when rigon mortis set in, instead of the expected anterior convexity in the thoracic region.

The left femoral head was found articulated in the acetabulum (hip joint), but broken at the neck, and its position suggested while person's leg was in extension, that is, seated. It is possible that the left proximal femur had been fused to the acetabulum (ankylosis of the hip joint) in life, but the angle of the femoral head, with the leg in extension makes this unlikely. There is still tissue completely surrounding this joint, making non-invasive macroobservation difficult, but one explanation for this finding is that the leg was broken off when the surrounding tissue made it difficult for those processing the remains to remove it cleanly.

Interpretation: These findings suggest that there was a mortuary ritual involved that resulted in the current state of preservation of the UM2010.1 female. Notable features include the application of the pink pigmentation, the curved vertebral column, the broken ribs, and the absence of all long limb bones except for the remaining left femoral head. These are traits characteristic of regional (Upper Mustang) Bon funerary practices for an adult, as described by Ramble (1982) for the Lubra village of Muktinath. In particular, upon death the deceased is "bound into a sitting position with the feet together and the knees drawn up" (Ramble 1982:335). Then the back of the deceased is broken at the neck as the head is snapped forward and "the head is then pushed down between the knees and the corpse is left to stiffen in that position" (ibid.). These steps in the funerary ritual in Lubra can explain the high angulation of the left femoral head in UM2010.1, which suggests the seated posture, perhaps with knees tucked up, as well as the anteriorly concave spinal curvature. Following this, a ritual specialist dismembers the body, chopping the body, including the skull and long bones, down to parts consumable by vultures. While dismemberment may have occurred with UM2010.1 since no long bones are found, the later portion of the funerary ritual does not neatly mirror our findings as th e axial skeleton, including the skull, is left intact, although the ribs are broken. The breakage of the rib cage may have been by deliberate human processing; Ramble relates a

personal communication by Graham Clarke who did fieldwork in Mugu, where victims of "bad death" (e.g., died by violence, accident, childbirth, suicides) are mutilated with a knife and have their ribcages inverted during the air (aka sky) burial ritual (Ramble 1982:355-356). These descriptions of the broken neck, bent legs, dismemberment and defleshing, and exposing internal abdomen in the event of illness are similar to those of a "eye witness" to such a ritual in Western Tibet in 1933 (Singh 1933). Ramble's description does not record the application of pink pigment on the remains in the Bon tradition in Lubra.

The Zoroastraian burial practice of offering the flesh of deceased to animals spread to Tibet around the turn of the second millennium CE (Stoddard 2009), and this 16th c. burial appears to fit the pattern in many ways. It may be that the mortuary ritual in Jyongkyore (and Gongphu, described below) was quite similar to the first steps of funerary treatment found today in Lubra (and/or Mugu) for a Tibetan sky burial, but over time, or with local variation, differences accrued in mortuary treatment. That is, the deceased in the Jyongkyore community of the past were not completely dismembered and the application of pink pigment was practiced.

It is possible that scavengers or predators could have caused the long limb dismemberment and removal of the ribs. There were feathers adhering to the skeleton and found throughout the cave in which it had been deposited, suggesting the presence of vultures, which could have broken the ribs, and/or eaten the tissue on the long bones and dispersed them elsewhere. Studies of the modification of bone due to vulture behavior showed that while some strong connective tissue does continue to articulate some elements, the mandible, cranium and limb bones disarticulated, with the majority of flesh consumed within 48 hours and skeletonization occurring within 96 hours (Reeves 2009). Vultures leave two types of markings on the bone. First, are relatively shallow scratches that measure up to 4 cm in length, typically in the skull; these are relatively linear but irregular shaped so they usually not mistaken for those from sharp force trauma (ibid: 526). The second form of modification is a linear scratch that does not penetrate bone, so is characterized by a change in color on the surface of the bone. No such markings were observed on the bones I observed. Also, the fresh tracks of an animal, said to be those of a snow leopard by the locals who joined us, were found during our team's trek to the Jyongkyore cave. Such predators were probably present in the past and cats are known to be opportunistic feeders, which includes carrion (Edney 1982). There was no evidence of puncture marks from any carnivore on the vertebrae, pelvis, or skull, however, excluding them as causes for state of the finds. Alternatively, the absence of the limb bones may have been deliberate, in that they were removed as relics. Such an act is found in Tibetan rituals, though it may be unlikely in this case as bone relics derived from women are extremely rare (Martin 1994:277).

Gongphu ("Wine Bottle Cave" outside Choesar) had axial elements for three individuals *in situ* that I examined on July 31, 2010. The skulls were curated in kathmandu's DoA, and examined 8/11/2010. Slight tissue residue on all burials, especially UM2010.2, prevented closer examination of potential lesions. Note, faunal remains were also discovered in the caves among the Gongphu remains, with pink pigment found on some of them (perhaps plaster?): two long bones of larger animals, and 2 smaller ribs (which had no pink pigment).

UM2010.2

These were the remains of an adult male. Left *in situ* within the cave was the axial skeleton including the second cervical (C2) down to the pelvis. The remains were partially desiccated from C5 down to the sacrum, with skin extending on right ribs 6-12, also with dried thin tissue covering all bones and points of articulation, so not much could be examined skeletally with respect to potential lesions. A skin sample had been removed in 2008 (linear blade cut) from

posterior around lumbar 2 to L3 of back; we took a small sample from the left waist above ilium. There is a left curvature of cervical thoracic down to thoracic 12, similar to the curvature described for Jyongkyore UM2010.1, although more left leaning vs. anterior.

At the DoA I examined the skull which had cervical 1 (C1) attached; this complements the rest of elements present in the caves. There was much tissue on the skull vault, especially parietal/occipital. The right upper canine and third premolar (P3) were present but broken at the cementum enamel junction (CEJ) without crowns and there was only the mesio-buccal root of right M1 (so no teeth to sample), with postmortem loss of all (13) remaining teeth.

UM2010.3

These were the remains of an older adult male. Left in cave was the axial skeleton of C7 down to pelvis (later matched to the DoA Gongphu skull which had C1 to C6). Eight rib heads had been left attached to thoracic vertebrae, with three located on the left: ribs 3, 6, and 8; and five on the right: ribs 3, 4, 6, 8, and 9; in addition there were 11 fragments of ribs on both sides (not complete heads). There was vertebral curvature to the right, from T8 and up cranially. Vertebral osteophytosis was present on all five lumbars. The hips had acetabular DJD on both sides.

On the skull, which I examined at the DoA 8/11, there was much tissue on skull vault around the parietal and occipital. There was antemortem tooth loss of three teeth: upper left P4 and M2 and right I1; resorption of alveolar bone around upper right M1, left M1 and left M3, with postmortem loss the rest of the teeth.

UM2010.4

These were the remains of an adult female. The axial skeleton left in the cave included thoracic 1 (T1) to pelvis. There was a slight spinal curve to the right around mid thoracic. A tissue sample was taken from the right ischial callosity.

The female cranium located in the DoA did not have any of the missing C1-7 cervical vertebrae, but the size and sex determination of the cranium matched the axial skeleton (all other had been males). The face had a postmortem break to the left zygomatic and maxilla, and the right maxillary portion from I2 to the second of third molar was present, but the bone was too damaged to see alveolus, with no teeth present. There was a postmortem cut on the left superior orbit's lateral edge, possibly made during from 2008.

Interpretation of Gongphu finds: These finds are very similar to the Jyongkyore burial, UM2010.1 in that: 1) only the axial skeleton was present; 2) ribs had been broken off (except in UM2010.2); and 3) there was an anteriorly concave spinal curvature in a "C" shape, though not as marked as in Jyongkyore. While no pink pigment was applied directly to these Gongphu burials, there were faunal remains with slight pink pigmentation. These findings suggest a similar mortuary treatment between these two cave systems, both located within the Choesar Valley of Upper Mustang.

B. Sam Dzong Caves of 2010

The skeletal material were found *in situ* in the Sam Dzong (SD) caves August 1, 2010, with full analysis occurring over the next two days as finds were divided from the two caves of Sam Dzong 1 (SD 1) and Sam Dzong 2 (SD 2).

Context and Preservation

Seven Caves are present in Sam Dzong site, with four larger caves along the larger face of the cliff (which faces the stream and valley), and three along another side that juts out perpendicular to that axis. SD 1 was explored first and has the most material analyzed here, while SD 2 was explored the next day and was not connected to SD 1.

Bones were found scattered along the bottom of the caves, and some had been exposed the bleaching effects of sunlight and repeated exposure to water, leading to cracking. These scattered remains had an MNI of three (two adults

and one juvenile), as well as faunal remains, but as they were not found *in situ*, they are not added to the MNI count of the Sam Dzong caves.

The preservation of the remains were present within the caves was relatively good for many elements. However, bones closer to the edge of the cave entrance were in danger of eroding off the cliff face, which led to their damage from the elements. The bones were generally intact, although some had become fragmentary or broken, possibly as a result of the repeated placement of burials on top of each other. There was little to no sign of carnivore activity, but one os coax has potential puncture marks from a carnivore. There were similarities to the Mebrak culture described by Alt and colleagues (2003) in that there were goat (and horse) heads, wooden boards that may be similar to the burial beds described for Mebrak, but also pottery that may be associated with the Chokhopani style (see archaeological report). These faunal remains were not intact, but due to time constraints no further analysis was performed beyond noting their presence.

Within SD 1 and SD 2, there were a minimum of 135 relatively intact bones found in the following categories in Table 1. Note, as discussed in more detail below, several bones had cut marks:

Table 1. Sam Dzong bone inventory and presence of cut marks

Bone	Number	Cut mark	% cut mark
Cranium	10	1	10%
Mandible	5	1	20%
Scapula	5	4	80%
Sternum	1	0	0%
Rib	17	11	65%
Vertebrae (cervical to lumbar)	7	0	0%
Humerus	17	7	41%
Ulna	4	2	50%
Radius	3	1	33%
Os coax	15	8	53%
Sacrum	3	0	0%
Femur	29	15	52%
Tibia	9	3	33%
Fibula	6	3	50%
Ankle (calcaneus)	2	0	0%
Foot (MT4 and MT5)	2	0	0%
Wrist/hand	0	-	-
Clavicle	0	-	-
Total	**135**	**56**	

Demographic Profile

As described earlier, MNI of Sam Dzong was determined by assessing the sub-MNI within each discrete area of concentrated bone "piles," found in each of the two caves. The bones were loosely concentrated and disarticulated, and the limited representation of bone types (such as vertebral elements and those of the smaller bones) all suggest that this was not a site of primary deposition, but instead a place of secondary burial. There is an MNI of 27 individuals, 17 from Sam Dzong 1 and 10 from Sam Dzong 2 (Table2). Note, if we based MNI purely on age and sex of individuals from both caves (rather than as determined through tallying up sub-MNI within the burial "piles"), then there would be an MNI of 25 (seven subadults, 10 adult females, and eight adult males). This count is somewhat less than the MNI derived from the method of determining sub-MNI to the discrete concentrations of bones, and does not account for contextual information of cave location of the burials, so we continue with the final tally of MNI at 27.

Table 2. Demographic profile of Sam Dzong (SD 1 and SD 2) caves

Code	Years	MNI Sam Dzong	Female	Male
I	Neonate to 2 yrs	0		
C	Child (3-6 yrs)	4		
J	Juvenile (7-12 yrs)	1		
Adol	Adolescent (13-19 yrs)	2	1	
YA	Young adult (20-34 yrs)	2	1	1
MA	Middle adult (35-50 yrs)	3	1	2
OA	Older adult (50+ yrs)	1		1
A	Adult of unknown age (20+ yrs)	14	8	4
	TOTAL	**27**	**11 Females**	**8 Males**

Adults comprise the majority of finds (74%, 20/27), especially those of indeterminate age as many finds lacked elements such as the pelvic bones or cranial sutures for a more specific determination of adult age category (Figure 15).

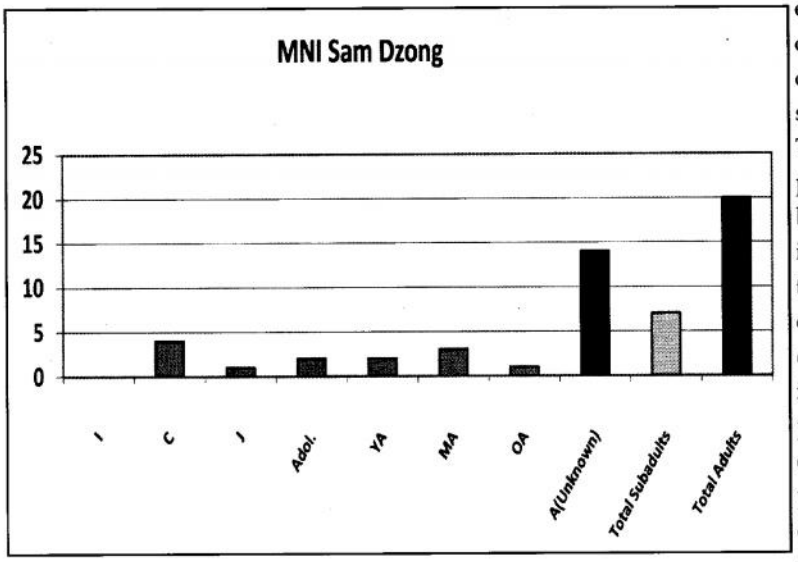

Figure 15. Demographic distribution of individuals from Sam dzong caves

Sam Dzong 1

Of the MNI of 17 individuals, three are children of unknown sex, one is an adolescent female, one is a YA female, four are MA males, two are OA (1 female, 1 male), 1 OA individual of indeterminate sex, and five individuals are adults of unknown age (1 female, 4 males).

Sam Dzong 2

Of the MNI of 10 individuals, three are subadults (1 child, 1 juvenile, 1 adolescent, all of unknown sex), one YA male, 1 MA female, and five adults of unknown age (1 male, 3 females, 1 of indeterminate six).

The overall underrepresentation of subadults (26%, 7/27), especially those in the youngest infant age category may suggest damage to these smaller fragile bones that prevented preservation (Bello, et al. 2006; Gordon and Buikstra 1981). The same may be true for the underrepresentation of adults in the oldest age category, where osteoporosis and osteopenia, particularly among older females, may have made bones less likely to preserve (Bennike 1985; Walker, et al. 1988). Alternatively, or concurrently, there may be cultural factors involved in this skewed demographic profile. These factors include burial practices that exvluded the burial of younger individuals in the caves or that lead to the biased preservation of older children and adults. As discussed below, the majority of individuals in these caves show postmortem processing, with cut marks, which suggest burial practices may have skewed the demographic distribution of the burial samples.

Cut Marks on Sam Dzong Skeletal Remains

Cut marks were observed in the majority of individuals from both caves. They do not resemble marks made by animal activity such as that of vultures, which are known to accumulate bones in caves, but which leave diagnostic marks on bones and have a preference of bone types not found here (Reeves 2009; Robert and Vigne 2002). These cut marks are the result of deliberate human activity as evidence by the symmetry and repeated pattern and distribution of the cuts across common areas of bone types, as well as the cut morphology, which were shallow, sharp edges that were "V" or "U" shaped and less than 1 mm in width, indicating the use of a sharp implement. Note, these marks were examined macroscopically and with the use of estimates. These cut marks were not the result of our recovery of these remains as no sharp implements were used and there was no sign of more recent entrance into the caves, which required highly technical cave

climbing and rappelling into them. Furthermore, the similarity in the color of the interior of the cuts with surrounding bone surfaces, including embedded dirt in some instances suggests the cuts are not recent.

Cut marks were tallied by the number of cut marks found on each bone element observed, the number of cut marks per element type, and the number of individuals with cut marks where possible (several elements could not be associated with a known burial number), including sex and age of individuals. When calculating the total number of elements that had been observed, elements that had become fragmentary (e.g., cranium or long bone) were counted as one piece. Of the 135 relatively whole bones that were observed, 56 (41.5%) had cut marks. As noted in Table 1, several bone categories (e.g., vertebrae and foot) did not have cut marks, with 11 element types (total of 120 bones) that had cuts: the cranium, mandible, scapula, ribs, humerus, ulna, radius, os coax, femur, tibia, and fibula (Table 3). These counts included elements that could not be definitively associated with known individuals within the burial piles (e.g., labeled "UM2010. #miscellaneous").

Table 3. Summary data of cut marks observed in Sam Dzong burials

Bones with cut marks	# Cut marks	# Bone type obs.	Cut/ Bone type %	Cut/56 cut bones %
Femur	15	29	52%	26.8%
Rib	11	17	65%	19.6%
Os coax	8	15	53%	14.3%
Humerus	7	17	41%	12.5%
Scapula	4	5	80%	7.1%
Fibula	3	6	50%	5.4%
Tibia	3	9	33%	5.4%
Ulna	2	4	50%	3.6%
Carnium	1	10	10%	1.8%
Mandible	1	5	20%	1.8%
Radius	1	3	33%	1.8%
# Bones w/ cut marks	56	120		100%

The element that was the best represented in the assemblage was the femur (n=29), with the highest raw number of bones with cut marks, where 52% (15/29) femora show cuts, which accounts for nearly 27% (15/56) of all bones with cut marks. Table 3 summarizes these data, with ribs, then os coax, humerus, scapula, etc. represented in decreasing frequency in their representation for cut bones. Note that the scapula shows the highest frequency of cut marks, where 80% (4/5) of scapula observed show cut marks, followed by the rib, os coax, then femur, and so on, with the lowest frequency in the skull, where just one cranium (1/10) and one mandible (1/5) have cut marks.

Table 4 provides an inventory and description of the location of cut marks and their measurements. The cut marks are equally distributed between left (50%, 28/56) and right (46.4%, 36/56) sided elements, with two bones, both latter halves of ribs that could not be sided. The average number of cuts areas on a bone (e.g., located on the proximal third, shaft, or distal third of a long bone, or medial, lateral, superior or inferior portion of an irregular bone), was 1.3. Thus, usually one area was targeted, but occasionally, more than one region of a bone was cut. Several areas of bones with cut marks had multiple cuts, suggesting successive, or repeated strikes. The average number of cuts within a targeted area was 3.7 cuts. That is, within an area that has been cut, such as the proximal femur, there is more than one cut, for an overall average of 3.7 cuts per region on a bone. The single bone with the highest number of cuts was a right scapula (from the UM2010.8 miscellaneous collection) with 14 cuts, followed by a rib from the UM2010.6 burial, with 13 cuts.

Table 4. Description of cut marks among Sam Dzong individuals

Burial ID	Age	Sex	# cut bones/ind	Bone	Side	# cut areas/bone	Location	# cuts/ area	Msr 1	Msr 2	Msr 3	Msr 4	Msr 5	Msr 6	Msr 7	Msr 8	Msr 9	Msr 10	Msr 11	Msr 12	Msr 13	Msr 14	Avg cut mm
UM2010.5a	A	M	1	Humerus	R	2	1) Prox:superior head	2	17.3	7.8													12.6
							2) Prox:neck	2	5.7	5.0													5.4
UM2010.5b	A	F	3	Femur	R	2	1) Prox:Intertro chanter/superior	1	4.6														4.6
							2) Prox: below tro chanter (posterior	5	3.9	2.6	2.1	0.9	0.8										2.1
				Radius	L	1	Dist: anterior	1	3.2														3.2
				Os coxa	R	3	1) Bentral ilium	6	8.1	11	12	8.3	9.9	11									10.0
							2) Dorsal ilium near post spine	3	31.5	14	4.6												16.7
							3) Ischial tuberosity	2	4.6	2.3													3.5
UM2010.6	A	F	2	Rib	R	1	Ventral angle	2	6.6	14													10.5
				Rib	R	1	Ventral neck to angle	13	3.6	7	6.8	6.1	4.7	8.8	10	9.3	7.9	11	3.6	2.8	2.5		6.4
UM2010.7c	MA	M	2	Os coxa	L	1	Dorsal ilium	4+	11.3	13	4.2	21											12.3
				Os coxa	R	1	b/n Alls and ischial tuberosity	4	4.4	4.4	1.9	2.6											3.3
UM2010.7d	OA	M	1	Os coxa	R	1	Dorsal ilium	8	7.4	5.7	4.8	20	5.5	11	15	6.7							9.5
UM2010.7(misc)	A	Unk	(5)	Rib	?	1	Ventral near sterna end	1	3.7														3.7
	A	Unk		Scapula	L	1	Ventral angle	2	3.6	3.4													3.5
	A	Unk		Scapula	R	1	Superior spine	1	8.6														8.6
	A	Unk		Humerus	R	1	Shaft: below prox	1	4.1														4.1
	A	Unk		Femur	L	1	Prox: subtrochanteric, neck	3	10	9.6	5.2												8.3
UM2010.8(misc)	A	Unk	(6)	Rib	L	1	Dorsal angle	2	8.1	12													10.3
	A	Unk		Rib	L	1	Dorsal angle and curve	7	8.7	8.2	5.3	5.9	8	8.9	11								7.9
	A	Unk		Rib	L	1	Dorsal angle	5	4.8	7.1	4.2	4.4	7.2										5.5
	A	Unk		Scapula	R	4	1) Spine	14	5.2	5.2	13	10	9.8	3.3	9.3	12	9.1	2.1	12	10	5.2	7.5	8.2
							2) Superior border	3	3.2	3.2	2.5												3.0
							3) Infraspinoufossa	5	37.2	5.9	7.4	3	7										12.1
							4) Lateral border to margin	12	5.7	4.2	2.1	7.7	4.2	1.9	4.9	25	19	6	14	7.8			8.5
	A	Unk		Femur	R	1	Prox: subtrochanteric	2	13.1	7.2													10.2
	A	Unk		Femur	L	1	Prox: below greater troch, anterior	2	4.1	11													7.6
UM2010.9b	Adol	F	2	Femur	L	2	1) Prox: (b/n head and gr. Troch)	4	2	5	2.6	6.2	4.3										4.0
							2) Prox: subtroch ant-lat	6	5	2.7	2	4.1	6.1	2.3									3.7
				Os coxa	R	2	1) Ventral ilium near Alls	7	10	6.1	7.4	9.3	2.7	4.6	6.3								6.6
							2) Ilium dorsal near GSN	1+	11.3														11.3
UM2010.9(misc)	A	Unk	(10)	Humerus	L	1	Prox: posterior neck	2	3.3	5.5													4.4
	A	Unk		Humerus	L	1	Dist: posterior	2	11.5	9.8													10.7
	A	Unk		Ulna	L	2	1) Dist: medial	3	2.5	2	2.5												2.3
	A	Unk					2) Prox: trochlearlip	2	3.3	3.2													3.3
	A	Unk		Femur	R	1	Prox:trochanter, lateral	4	1.6	2.2	8.7	9.9											5.6

	A	Unk		Femur	R	2	1) Prox: intertroch	2	8	4.6											6.3
							2) Prox: gr. Troch. and below	3	5.8	3.3	2.1										3.7
UM201.9(misc)	A	Unk		Tibia	R	1	Dist:anterior shaft	2	4	3.5											3.8
	A	Unk		Fibula	L	1	Dist: anterior	8	3.4	3.2	4.1	2.5	2.8	9.2	11	7.5					5.5
	A	Unk		Rib	L	1	Ventral angle	3	4.6	4.1	4.3										4.3
	A	Unk		Rib	L	1	Ventral angle	3	6.8	10	9.9	11									9.4
	A	Unk		Rib	?	1	Shaft: ventral sterna end	4	5.5	4.1	3.5										4.4
UM2010.10a	A	F	1	Cranium	L	1	Parietal above ant. Squamous	3	7.5	5.2	7.9										6.9
Um2010.10e	YA	M	1		L	2	1) Ramus buccal	4	4.3	3.7	4.9	3.4									4.1
							2) below P4/M1, buccal	1	3.4												3.4
UM2010.10i	Juv	Unk	1	Femur	R	2	1) Prox: neck	2	8	3											5.5
							2) Prox: subtroch.	2	4.4	3.9											4.2
UM2010.10j		Unk	1	Tibia	L	1	Prox: posterior shaft	2	4.2	3.6											3.9
	A	Unk	(19)	Ulna	R	2	1) Prox: posterior neck	9	7.2	2.7	5.2	5.9									5.3
	A	Unk					2) Shaft: parallel interosseus crest	2	4.4	3.7											3.9
	A	Unk		Humerus	L	1	Prox: posterior neck	3	3.6	3.8	2.8										3.4
	A	Unk		Humerus	R	1	Prox: posterior shaft	6	6.4	8.1	12	10	6.2	8.9							8.6
	A	Unk		Humerus	R	1	Dist: shaft	3	6.1	3.1	2.8										4.0
	A	Unk		Femur	L	1	Prox: anterior shaft	4	3.9	3.2	6.3	3.1									4.1
	A	Unk		Femur	L	1	Dist: anterior & posterior	4	7.6	10	4.7	3.2									6.4
	A	Unk		Femur	R	1	Prox: subtroch	6	4.1	4	5	2.5	4	5.6	6.5						4.5
	A	Unk		Femur	R	2	1) Prox: lateral neck	1	7.9												7.9
							2) Shaft: midshaft	1	39												39.0
	A	Unk		Femur	R	1	Prox: neck	1	4.1												4.1
	A	Unk		Femur	R	1	Dist: posterior shaft	1	7.8												7.8
	A	Unk		Femur	R	1	Dist: lateral shaft	6	4.4	6.3	2.5	3.2	3.6	1.8							3.6
	A	Unk		Tibia	L	1	Dist: anterior and medial	5	8.2	9.4	7	11	4.9								8.2
	A	Unk		Fibula	L	1	Dist: lateral	3	4.9	3.4	4.1										4.1
	A	Unk		Fibula	L	1	Prox: neck to shaft	5	5.4	5.8	11	4.7	7								6.8
	A	Unk		Os coxa	L	1	Ventral: Alls	1	5.7												5.7
	A	Unk		Os coxa	L	2	1) Ilium ventral	2	12	11											11.7
							2) GSN	6	5.4	2.7	3.3	2.7	2.7	3.7							3.4
	A	Unk		Os coxa	R	2	1) Dorsal ilium	5	11	5.3	4.7	4.8	3.2								5.8
							2) Ventral ilium	3	19	21	15										18.0
	A	Unk		Scapula	R	2	1) Spine	6	3.9	6.8	15	13	2.6	4.6							7.7
							2) Medial border	3	6.6	3.6	6.6										5.6
	A	Unk		Rib	L	2	1) Dorsal tubercle, neck	2	3.9	6.3											5.1
	A	Unk					2) Shaft of rib	1	3												3.0
	A	Unk		Rib	L	1	Ventral neck/angle	5	6.3	7.8	8.6	8.7	5.6								7.4
MNI=17				**56 bones**		**1.3**		**3.7**													**6.8**

The average length of the cut marks measures 6.8 mm. Several cuts are relatively short at just under 1mm, and some are long cuts with the longest at 37.2 mm, found on the infrascapular fossa of a scapula. It is likely the surface area on which to cut affected the length of cuts. Many cuts were found on "complex" areas, that is, the neck region of bones, which may account for the shorter cuts, compared to the longer cuts found on the os coxa and along diaphyseal shafts that have more surface area. As mentioned previously the bones with highest frequency of cuts were the scapula, rib, and os coxa, all of which are somewhat complex in shape, where the scapula and os coxa are irregular bones with multiple surfaces, and the rib is narrow and angled.

Overall, from an MNI of 27 individuals within the two Sam Dzong caves, 17 (63%) individuals displayed at least one cut mark (Table 5). Among the 20 adults, 14(70%) had cut marks, and among the seven subadults, three had cut marks (42.9%). When considering the cave sites individually, within the five burial "piles" of SD 1 (i.e., UM2010.5 to UM2010.6) at least one person per burial had a cut element, with a minimum of nine individuals (out of 17,52.9%) from SD 1 with cut marks. These include eight adults (three males, two females, and the rest of indeterminate sex) and one adolescent female. Within SD 2, which includes the burials UM2010.10a through UM2010. j, there are a minimum of eight individuals (out of an MNI of 10, 80%) with cuts. Six are adults (one male, one female, and the rest of indeterminate sex), one is an adolescent, and one a juvenile.

Table 5. Frequency of cut marks among Sam Dzong individuals

Category	#cuts	% per category
Total Individuals	17/17	63.0%
#Adults	14/20	70.0%
#Subadults	3/7	42.9%
SamDzong 1	9/17	52.9%
SamDzong 2	8/10	80.0%

Among the 17 individuals with cut marks, although sex could not be determined for some individuals, at least four males and four females (all adult, except one adolescent female) had cut marks. The other adolescent and juvenile were of indeterminate sex. Among the adult males, the age range of cut individuals contained those that fell into the young, middle, and old adult age categories. The distribution of cut marks across the age groups from juvenile to old age, and among adult males and females suggests relatively equal mortuary treatment across age and sex. But it must be remembered that the demographic profile of the Sam Dzong caves does not show a typical distribution of a mortuary population, with underrepresentation of the very youngest and oldest age groups.

Interpretation of cut marks:

The cut marks were made by deliberate human actions and were not made antemortem as there is no sign of healing in any of them. They may have been made not long after death as the bones with the most processing (number of cuts on individual bones, as well as the frequency of bone with cuts/bone type) such as the scapulae, ribs, and os coxae did not disarticulate naturally from the surrounding tissue, necessitating the processing for removal. These bones, as well as long bones typically have the cut marks around articular regions, suggesting dismemberment, as well as areas where tendonous fascia formations or tough ligaments are found, suggesting defleshing (Raemsch 1993). That is in contrast to the areas of muscle and tendon attachment, where butchery of animal generally occurs to get the most flesh (Bendezu-Sarmiento, et al. 2008). In additiona to these three axial elements, the other two bones with the highest representation of having any cut marks are the largest long bones in the upper and lower extremity: the humerus and femur, again suggesting processing of fresh bone to remove flesh.

The context of the burial treatment and deposition suggests these were secondary burials, though other scenarios must be examined. The diagnostic patterns cannibalism have been well documented (e.g., Hurlbut 2000), and that can be ruled out for the Sam Dzong material. While cut marks are present and there is underrepresentation of vertebrae and signs of carnivore activity, the Sam Dzong remains lack

many of the other key taphonomic signatures of cannibalism including: extreme permimortem fragmentation, percussion/anvil breakage, and evidence of burning (e.g., pot polish) (Turner 1983; Turner and Turner 1990; White 1992). Those bones that were fragmentary did not have the characteristic spiral fracture pattern seen inflicted in instances of perimortem fracture for marrow extraction, but instead seem to be the result of weathering and the pressure of additional weight placed on top of the remains (Johnson 1985), for example that of more burials in reuse of the caves as a mortuary site. Secondary burials often include intentional disarticulation and defleshing of remains (e.g., Bendezu-Sarmiento, et al. 2008; Toussaint 2011), which can be misinterpreted as the patterns seen in cannibalism (Hurlbut 2000). The relatively intact nature of the bones and the care in which the deceased were deposited in hard to access caves (likely in the past as well as in the present), with suggest mortuary ritual involved in these secondary burials vs. the use of the caves for cannibalism or the deposition of victims of warfare.

Anthropologists have speculated on the origin of sky burials in Tibet and the links to earlier Zoroastrian funerary rituals (Wylie 1965). Stoddard's (2009) examination of the origins "decharnement" or defleshing in Tibetan sky burials, which post-date the Sam Dzong burials by some 500 years (see C 14 dates in archaeological report), describes the doctoral thesis of Franz Grenet, Grenet had found links between the Tibetan ritual and earlier Zoroastrian practices of defleshing and offerings of the flesh to animals, which he showed spread eastward from the beginning of the 1st century CE to the 10th or 11th centuries (Grenet, 1984: maps 2-5, as cited in Stoddard 2009). Thus, there may have been knowledge of these Zoroastrian practices in the Sam Dzong community. The Zoroastrian funerary rites also incorporated the practice of gathering bones that had been stripped (either by humans or by carnivorous animals) into receptacles, placed in a chamber or vault; this may be similar to the act of placing the processed bones into the Sam Dzong caves. Stoddard suggests that during the spread of these Zoroastrian rituals, parts of the rituals were transformed in variant practices and incorporated into local beliefs such as the Tibetan ritual of *gcod*, which became linked to the crushing the bones and offering everything to vultures and the like, which was adopted by Buddhists and Bon practitioners during the 11th and 12th centuries. The mortuary ritual associated with the Sam Dzong finds may be associated with the adoption of cultural practices from outsiders, or may be the product of more local practices that later evolved into the form of sky burials we see in the region today. Further examination of the other caves within Sam Dzong, including evaluation of the faunal remains, and comparisons to cemeteries from nearby locations can better illuminate this question.

Other Paleopathological Data of Interest

Dental Health

Among the 27 individuals of Sam Dzong, only the adults had teeth for observation, with fifteen out of 20 adults (75%) having at least alveolar bone to hold teeth, and eight individuals among them with teeth (53.3%). Nine adults had antemortem tooth loss (AMTL, 9/15, 60%), among them three males, five females, and one individuals of indeterminate sex. Among the 31 total teeth observed, there was only one adult (female of unknown age) with carious lesions on two teeth (6.5% teeth with carious lesions). Six individuals had abscesses (five of them females, 83.3%, vs. one male); for two individuals there was a single abscess, in three instances individuals suffered two abscesses, and carious lesions within the female sample suggest they suffered more oral health problems than males.

Age categories of those with dental disease were also noted, but only a few individuals could be placed in clear age categories. There was only one YA male and female each, both of whom suffered not dental disease; there were three MA males, two of whom had AMTL, and one MA female with no dental disease; and finally only one OA, a female who had considerable AMTL. The rest of the individuals with alveolar bone and/or teeth were adults of indeterminate adult age. These limited results suggest dental health suffered with increasing age, as expected.

Nonspecific Stress

None of the individuals with teeth to observe displayed linear enamel hypoplasia, lines that indicate growth disruption during the formation of tooth crowns during childhood development (Goodman and Armelagos 1985; Sarnat and Schour 1941; Schour and Massler 1945). Similarly, among the nine cranial vaults and 10 superior orbits, there are no signs of porotic hyperostosis, nor cribra orbitalia. Both have been linked with metabolic diseases such as anemia, scurvy, and other nutritional deficiencies that may stem from genetic or environmental causes including vitamin deficiencies and diarrhea from parasitic infection (Ortner, et al. 1999; Stuart-Macadam 1989a, b; Walker 1985; Walker, et al. 2009). There are also no signs of periosteal inflammation (periostitis) among the seven femora and two tibia observed. These results suggest relatively little stress experienced during growth and development, though the absence of such indicators does not necessarily mean these individuals did not undergo any stress, as they may have died *before* the development of stress indicators (Wood, et al. 1992).

Trauma

There were 68 long bones of the upper and lower limbs that were observed for trauma. The cut marks found on bones (31 of those cut bones located on the arm and leg) are discussed above, but none of these 68 bones displayed evidence of antemortem or perimortem fractures.

Carnial fractures and fractures to the facial bones such as the nose are indicative of interpersonal violence (Lovell 2008; Walker 1989, 1997). None of the eight individuals with nasal bones had fractures, but among the 12 crania observed, three individuals (25%) had cranial fractures (another individual, UM2010.10a had cut marks postmortem). One individual is a MA male, and the other two are female adults of indeterminate age. The male, UM2010.5a, has a healed blunt force trauma on the left posterior portion of the parietal, between the squamosal and sagittal suture; note, he also had postmortem cut marks on his humerus and a rib.

One female, UM2010.9c, has a fracture in the right temporo-parietal region, measuring 70.1 x 40.6 mm, with a radiating line from the sagittal to coronal suture. The second female, UM2010.10d, has two healed fractures: 1) one is on the superior right frontal, and extends up 6.2 cm, curving along the coronal suture, with sclerotic bone next to a gap near bregma; 2) the second is a healed depressed fracture also along the coronal suture, near the sphenoid with sclerotic bone, which may indicate infection.

The lack of postcranial fractures, even healed ones, suggest these individuals were not prone to accidental falls within this landscape. The presence of cranial fractures among 25% of the crania observed does suggest some interpersonal conflict. The tension may have been within the community, possible considering the healed nature of most of the wounds, or from intercommunity disputes. The healed nature of the cranial fractures and lack of other signs of violence suggest the caves were not used primarily as a depositional place for victims of warfare.

Joint disease

Not many of the long bones with joint articulation could be positively associated with known individuals from burials. Observation of degenerative joint disease (DJD) of the four major joints (shoulder, elbow, hip, and knee) is presented here. Among the three individuals with the shoulder joint for observation, not one had DJD. Two out of three individuals with the elbow joint had DJD: one MA male and one OA female. In the hip joint, three out of seven individuals had DJD: two MA males, and the same OA female with the elbow DJD. In the knee joint, not one out of the three observed had DJD. These limited results suggest that adults in the middle to old adult age category were more likely to suffer DJD, and that males may have had a higher frequency, though again, the data are very limited.

Stature

Stature was estimated based on maximum femoral length, as that was the numerous long bone and it is a relatively good proxy for height. The regression formulae chosen to estimate

stature were from Trotter (1979), with the formula for "Mongoloid male" chosen to estimate stature for the males, and (as there is no formula for "Mongoloid female") "White female" for the female stature estimation. These formulae are not population specific for Nepal populations, but provide reasonable approximations of height within this sample. There were three males with femora, with an average height of just under 5'5, and there were eight females with femora, for an average height of just under 5'0 (Table 6).

Table 6. Stature data among Sam Dzong adults, estimated from femoral length

Burial Number	Sex	Femur length	Stature (cm)	Stature
UM2010.9d	M	436	166.31	5'5.5
UM2010.7d	M	410	160.72	5'3
UM2010.10 misc	M	431	165.24	5'5
UM2010.8c	F	366	144.502	4'9
UM2010.5b	F	368	144.996	4'9
UM2010.8 misc	F	398	152.406	5'0
UM2010.10 misc	F	417	157.099	5'2
UM2010.10 misc	F	414	156.358	5'1.5
UM2010.10 misc	F	400	152.9	5'0
Average M		164.09 cm, s.d. 2.97		5'4.6
Average F		151.38 cm, s.d. 5.46		4'11.6

These height data can be compared to other high altitude populations, particularly those of Tibetan population affinity. Weitz and colleagues (2000) analyzed modern Tibetans in Qinghai Province, People's Republic of China, and found that average stature changed with increased altitude: 1) among males aged 20-29: 168.7 cm at 3200 m, 167.5 cm at 3800 m, and 166.2 m at 4300 m (Table 2, p. 74); 2) among females aged 20-29: 157.1 at 3200 m and 157.4 at 3800 m (Table 4, p. 75). The average height estimation of SamDzong males is shorter than that of all three in the modern comparative samples and likewise, the average Sam Dzong female height is shorter than the two comparative samples. Weitz et al. (2000) did not find a strong negative correlation between increased altitude and decreased height. The Sam Dzong results may be attributable to genetic predisposition to shorter average heights, or environmental conditions that constrained height at these times; these reasons are not mutually exclusive.

Biological affinity

Cranial measures were taken on skulls for intrasite and intersite comparisons to assess the relative homogeneity and heterogeneity within and between groups. These results are forthcoming.

C. Mebrak 92.5 and Chokhopani South 93.1

The burials from Mebrak, site 92.5, and the one burial from Chokhopani South, site 93.1, are curated at the Department of Archaeology in Kathmandu. The Mebrak finds had previously been examined, with reports of the excavation and burial analysis published elsewhere (e.g., Alt, et al. 2003; Simons, et al. 1998). They had not been examined since these original analyses for those reports and when examined by our team, were securely stored and wrapped by individual ("individduum" as noted earlier) burial. The following is a summary our findings from my 2010 reanalysis, beginning with Mebrak material.

Demographic profile

As noted previously (under "II. Determining Demographic Profile"), the Mebrak material had been given labels designating distinct individuals (Ind.). The ranged from Ind. 1 to Ind. 28, but four "Ind." From within that range were missing, Individuals 12,13,17, and 24. Furthermore, several wrapped remains had questions marks next to the labeled numbers, (e.g., "Ind. 5a?" and "Ind. 9?"), suggesting unclear association between elements and individual burial. Each box/bag with material (including the "Ind." finds) had inventory numbers beginning with "63" (e.g., 631-05, 632-25, etc). I determined MNI as detailed above, with an MNI of 42 individuals: 10 subadults (23.8%) and 32 adults (76.2%), with 17 adult males and 15 adult females (Table 7).

Table 7. Demographic profile of Mebrak 92.5

Code	Years	MNI Mebrak 92.5	Female	Male
I	Neonate to 2 yrs	3		
C	Child (3-6 yrs)	3		
J	Juvenile (7-12 yrs)	2		
Adol	Adolescent (13-19 yrs)	2		
YA	Young adult (20-34 yrs)	6	3	3
MA	Middle adult (35-50 yrs)	3	1	2
OA	Older adult (50+ yrs)	0		
A	Adult of unknown age (20+ yrs)	23	11	12
	TOTAL	42	15 Females	17 Males

Like the Sam Dzong demographic distribution, the number of males to females is relatively equal and there is underrepresentation of individuals from the oldest age category, though there are several infants from Mebrak. The overrepresentation of YA suggests a skewed distribution. The excellent preservation of these finds, where the majority had desiccated soft tissue still adhering, including the fully preserved, naturally mummified skeleton of an infant, "Ind. 25," suggests natural processes did not lead to disintegration of the older adult bones. Thus, there may be cultural factors explaining the exclusion of the oldest age groups within this burial sample.

Paleopathological Data

Note, the presence of desiccated tissue prevented the observation of many individuals for paleopathological conditions. For instance, jaws could not be opened to observe teeth, tissue covered the cranial vault and orbits, as well as the leg bones that were present, thus no lesions commonly found in these areas, or fractures or joint disease, could be observed. These limited the cases of observation, though preservation was excellent among these individuals. There was also only a single observation of cut marks on any of the bones with exposed bone, and these may have been made during the process of excavation or previous analysis. This is notable considering the finds in Sam Dzong had so many individuals with cut marks and the site had artifactual links to the Mebrak culture, including a wooden board similar to the bed boards described for this site, as well as a wooden ladle, and faunal remains that may have been sacrificial.

Dental Health

Among the 10 subadults, five individuals have alveolar bone and teeth for observation, at times both deciduous teeth and permanent teeth. There is no indication of AMTL, carious lesions, nor any abscesses.

Among the 32 adults, 20 have alveolar bone and 17 have teeth for observation. Seven individuals have AMTL (7/20, 35%): three males (1 YA, 2 indeterminate age) and four females (all of indeterminate age). There were 292 permanent teeth among the adults, with seven carious lesion observed (2.4%). Abscesses are found in three individuals (3/20, 15%): two males and one female, all of indeterminate age. As age could not be assigned more definitely for many of the adults, it is unclear if those of older age experienced more oral health problems. Males and females appear to have suffered equally from AMTL and abscesses, though males outnumber females in carious lesions and abscesses. Again, the limited sample size prevents more conclusive interpretations.

Nonspecific Stress

Linear enamel hypoplasia (LEH) is not found among the subadult dentition as there were no incisors or canines to observe. Among the adults only one YA male has a lesion on an incisor, where six individuals (16.7%) had incisors for observation. None of the eight adults with canines had LEH. Among both subadults and adults, there was no sign of porotic hyperostosis in the 11 total cranial vaults observed, nor indications of cribra orbitalia in the 18 individuals with orbits.

Trauma

The presence of desiccated skin limited the observations for fractures and evidence of healing on the crania and postcrania. Among the adults, 13 individuals had long bones that could be observed fully for fractures, 23 long bones of the arm and leg were available, none of which showed signs of fractures. Among the two subadults with long bones, there were also no fractures.

In the cranium, only one subadult could be observed, and there was no fracture. Two out of 15 adult crania (13.3%) had evidence of fractures. The young adult male 635-9 (Ind. 6) had a cranial fracture on the frontal, predominantly on the right side, with a healed arc from the supraorbital notch up to the left frontal beyond midline (from approximately the right supraorbital margin to the left frontomalare temporal); measures 66.5 mm + 36.4 mm across. A second individual, 633-104 (Ind. 23) is a female with an unhealed fracture that began with a trauma to the right frontal near bregma, which removed a large piece of bone and created radiating fracture lines. The lines radiated to the left frontal orbit (and continued lateral from it), to the right by nasal, and to both parietals.

Two out of 16 adults with nasal bones for observation had fractures (12.5%). One is an adult male, 633-79 (Ind. 19) with a healed fracture of the right nasal, and the second is an adult female, 631-10 (Ind. 1), which extended across both nasals and was in the process of healing.

The may be cut marks on one individual, 633-44 (Ind. 18) located on the body below PM2 (several scrapes measuring about 4.2 mm) and ascending ramus on the left mandible, although it is unknown whether these cuts were made in the process of excavation or previous examination (e.g., an attempt to remove adhering tissue to observe the underlying bone or for tissue samples, though no other signs of such removal are found).

Joint Disease

As so much desiccated skin or articular tissue covered the majority of bones, no observations were made for joint disease.

Stature

There were seven males with femora for stature estimation and six females (Table 8). Stature formulae used were the same as those used for Sam Dzong from Trotter (1970). The average height of males is 5'6.3, and for females it if just below five feet at 4'11.5, which are similar to the heights found in the Sam Dzong sample, although their average male height is a bit shorter.

Table 8. Stature data among Mebrak adults, estimated from femoral length

Burial Number		Sex	Femur Length	Stature (cm)	Stature
634-24	Ind. 3	M	410	160.72	5'3.3
635-4	Ind. 7	M	478	175.34	5'9
636-11	Ind. 5a?	M	468	173.19	5'8.2
633-53		M	450	169.32	5'6.7
633-52		M	437	166.525	5'5.6
633-77		M	438	166.74	5'5.7
633-51		M	435	166.095	5'5.4
634-13	Ind. 4	F	367	144.749	4'9
634-58	Ind. 21	F	387	149.689	4'11
633-33	Ind. 8	F	380	147.96	4'10.3
633-91		F	413	156.111	5'1.5
633-58	Ind. 5	F	400	152.9	5'0
633-79a	Ind. 19.1	F	409	155.123	5'1.1
Average M			168.28 cm, s.d. 4.87		5'6.3
Average F			151.09 cm, s.d. 4.00		4'11.5

Interpretation: The Mebrak finds have been analyzed previously with respect to paleopathological lesions and population affinity (Alt, et al. 2003). Regarding the former, results from my analysis were similar in several instances, e.g., the findings of two cranial fractures, though there are slight differences with respect to dental health results. Alt and colleagues (2003) reported 3.06% carious teeth vs. my finding of 2.4%. Such slight inconsistencies may be the result of interobserver error or use of different standards of protocol in determination of lesions. Regarding population affinity, the Mebrak finds may share similarities with the Sam Dzong samples as noted in the burial context with the use of wooden boards, presence of faunal remains, and possibly cut marks found on one person in Mebrak. However, that lone find is uncertain as it may have been made during the excavation or analysis, whereas the majority of Sam Dzong finds had cut marks. Further testing can be done via comparisons of craniometrics, aDNA analysis, and isotopic analysis.

Chokhopani South, site 93.1, 12-4

This was the lone sample I observed from this site, curated at the DoA. The remains consisted of a skull of a female, somewhat fragmentary, with mostly the left parietal, frontal, occipital,

both temporal, and the mandible. The lower left M1-3 and right M1 teeth were present and the rest had been lost postmortem. Age estimation from suture closure is middle age (about mid - 30's). No pathological lesions were observed.

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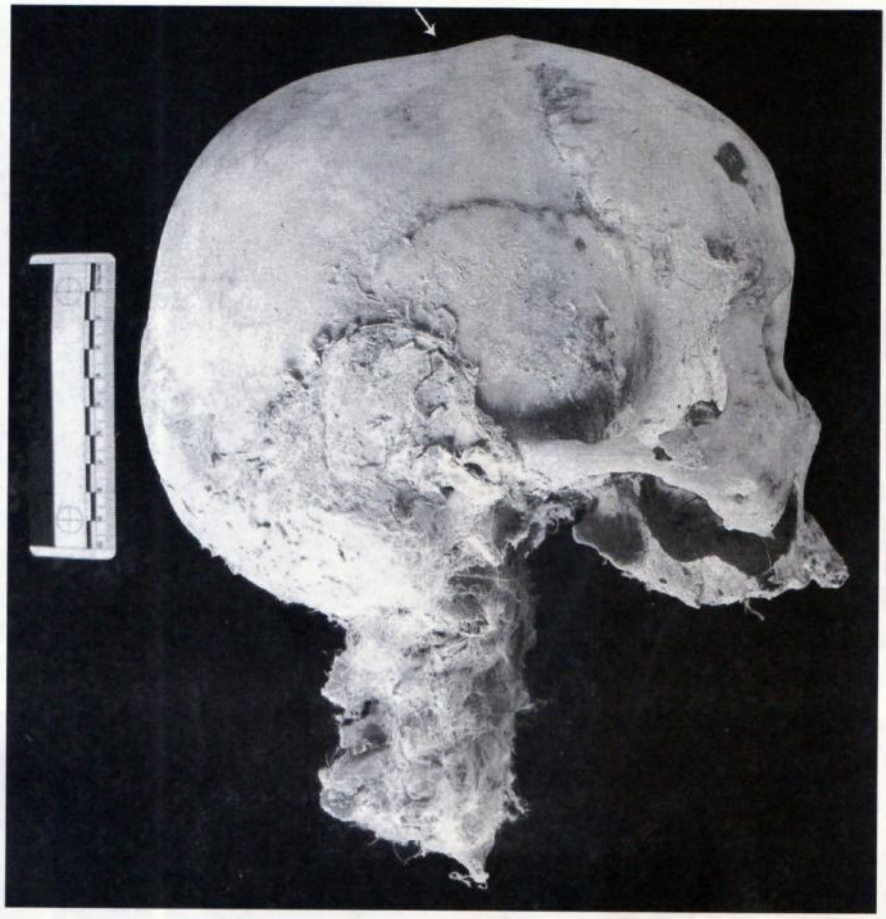

Figure 1. Right view of UM2010.1, with parietal depression behind coronal suture

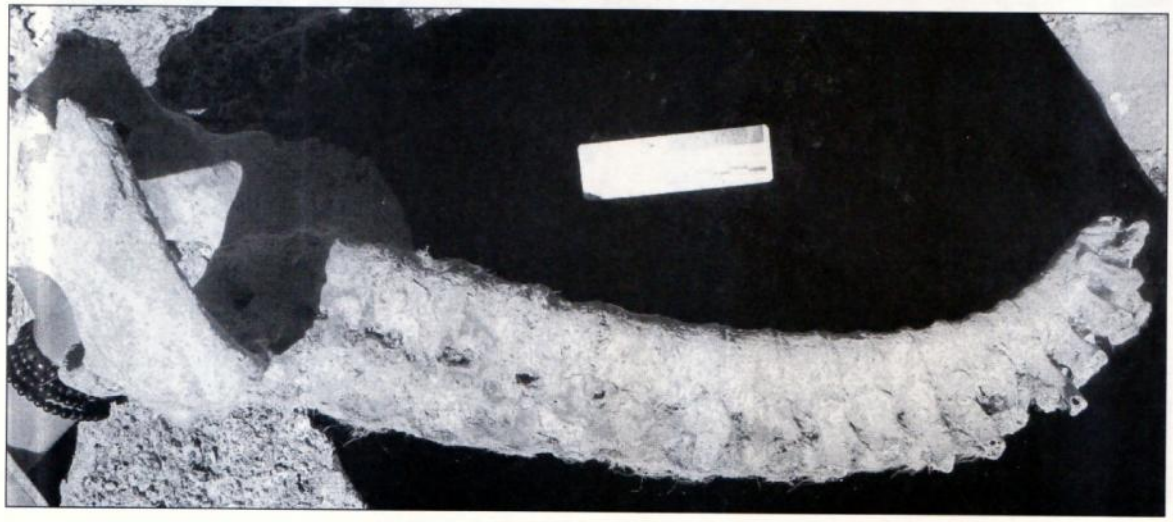

Figure 2. Primary curvature of UM2010.1 and pink pigment

Figure 3a, b. Left femur remains in the hip joint of UM2010.1 (a); close up view from laterial aspect

Figure 4. Gongphu remains (R-L): UM2010.2, UM2010.3, UM2010.4

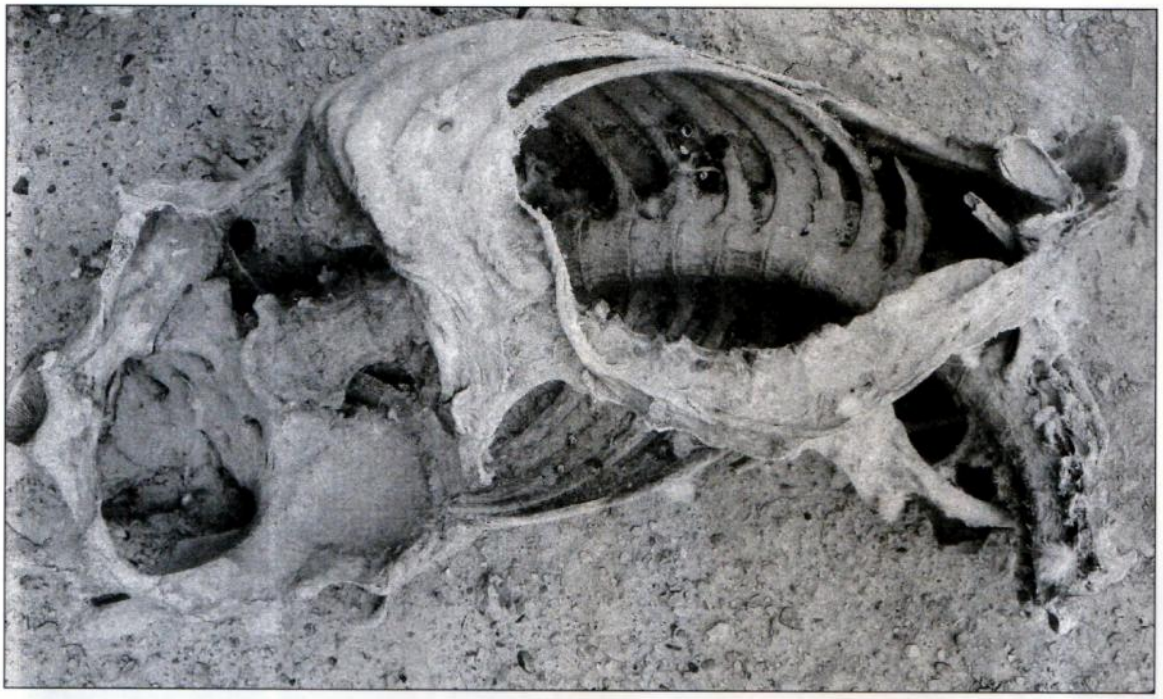

Figure 5. UM2010.2 male, anterior view

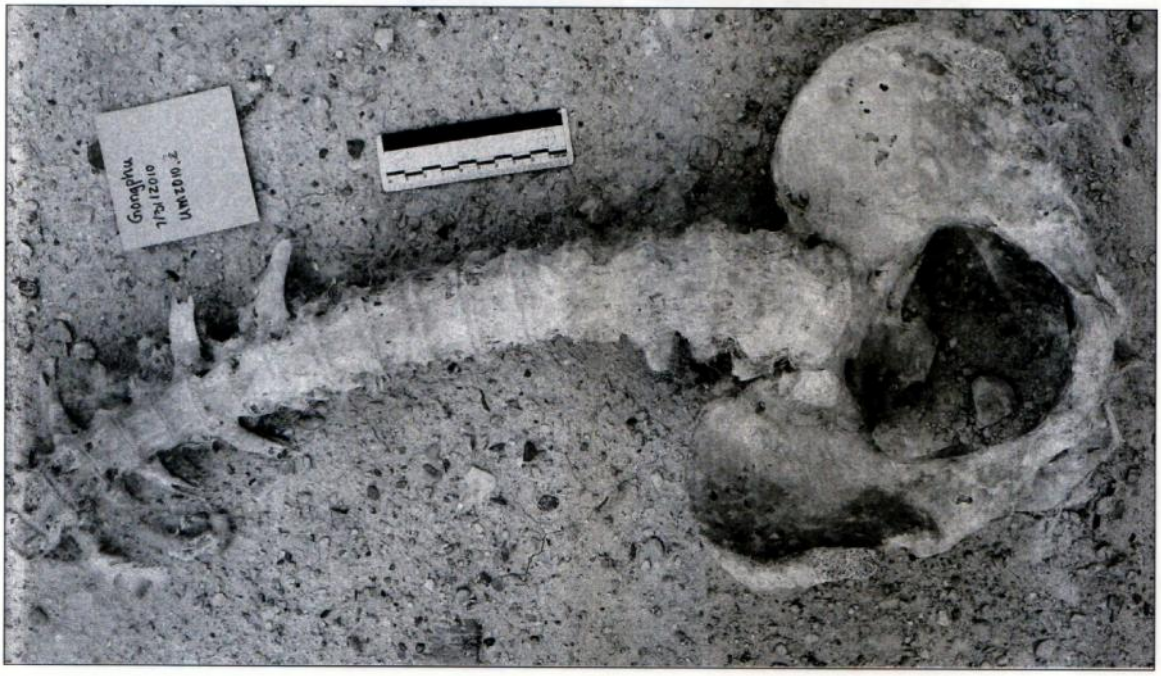

Figure 6. UM2010.3 male, anterior view

Figure 7. View of broken left ribs of UM2010.3

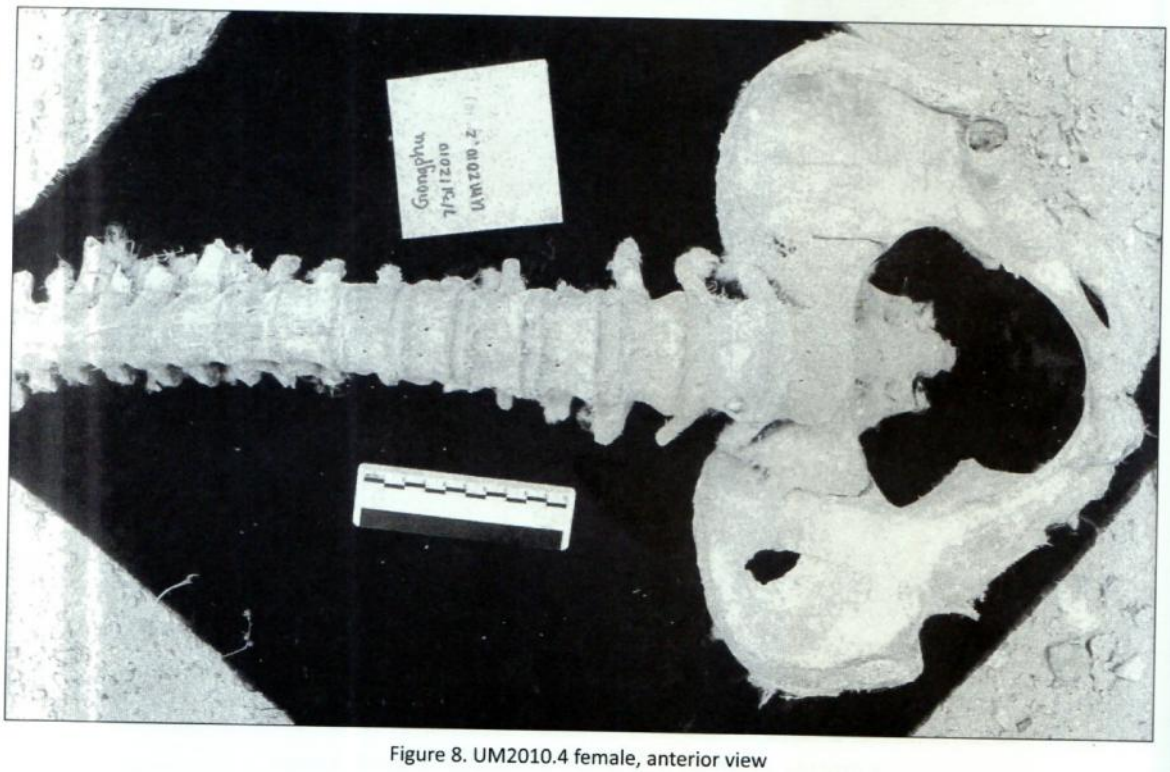

Figure 8. UM2010.4 female, anterior view

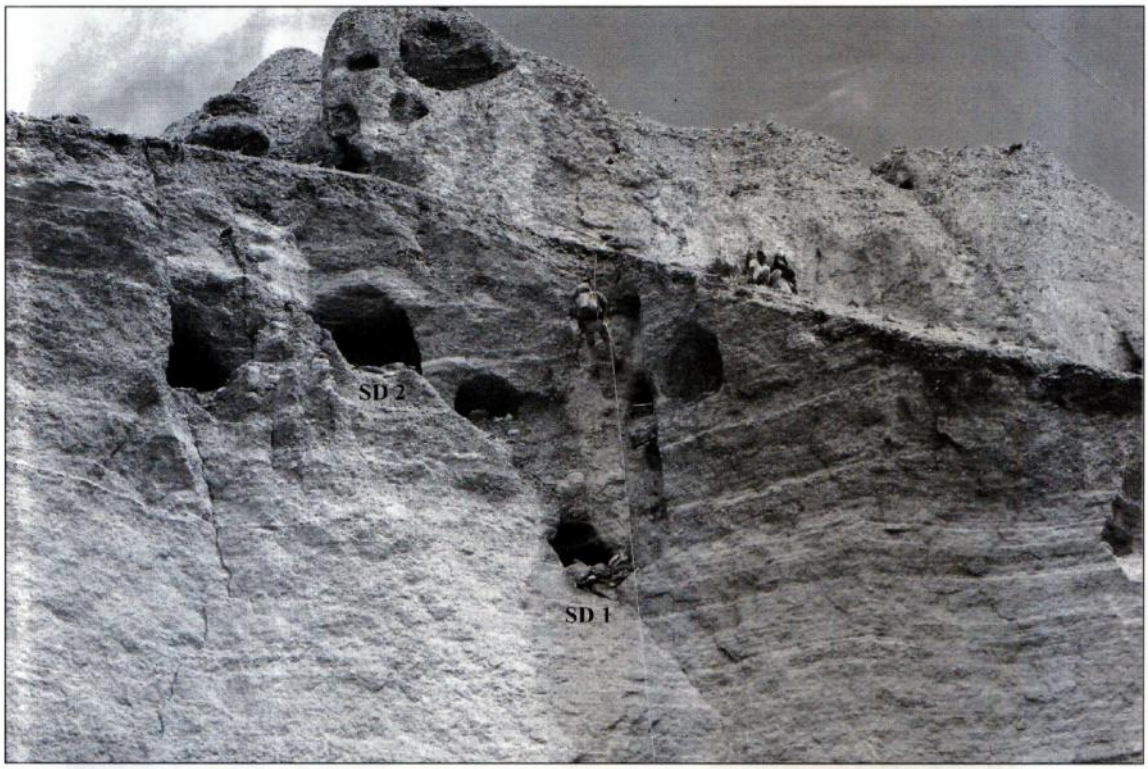

Figure 9. Caves of Sam Dzong. Note location of SD 1 and SD 2

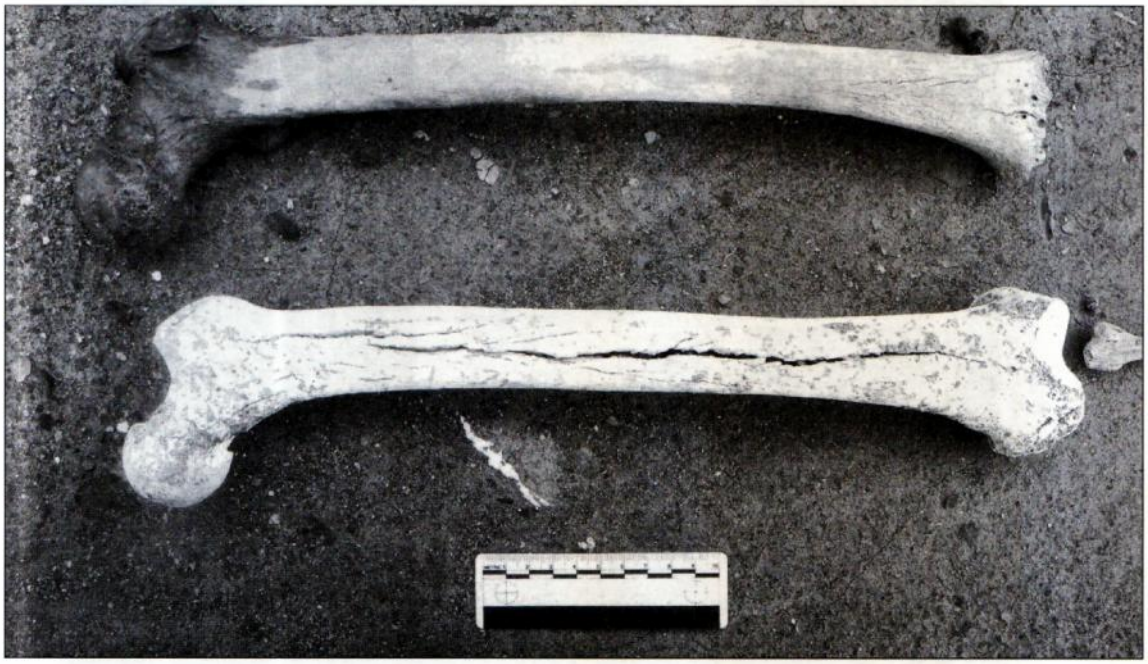

Figure 10. Bleached adult and wet adol femora

Figure 11. Wooden board, front view

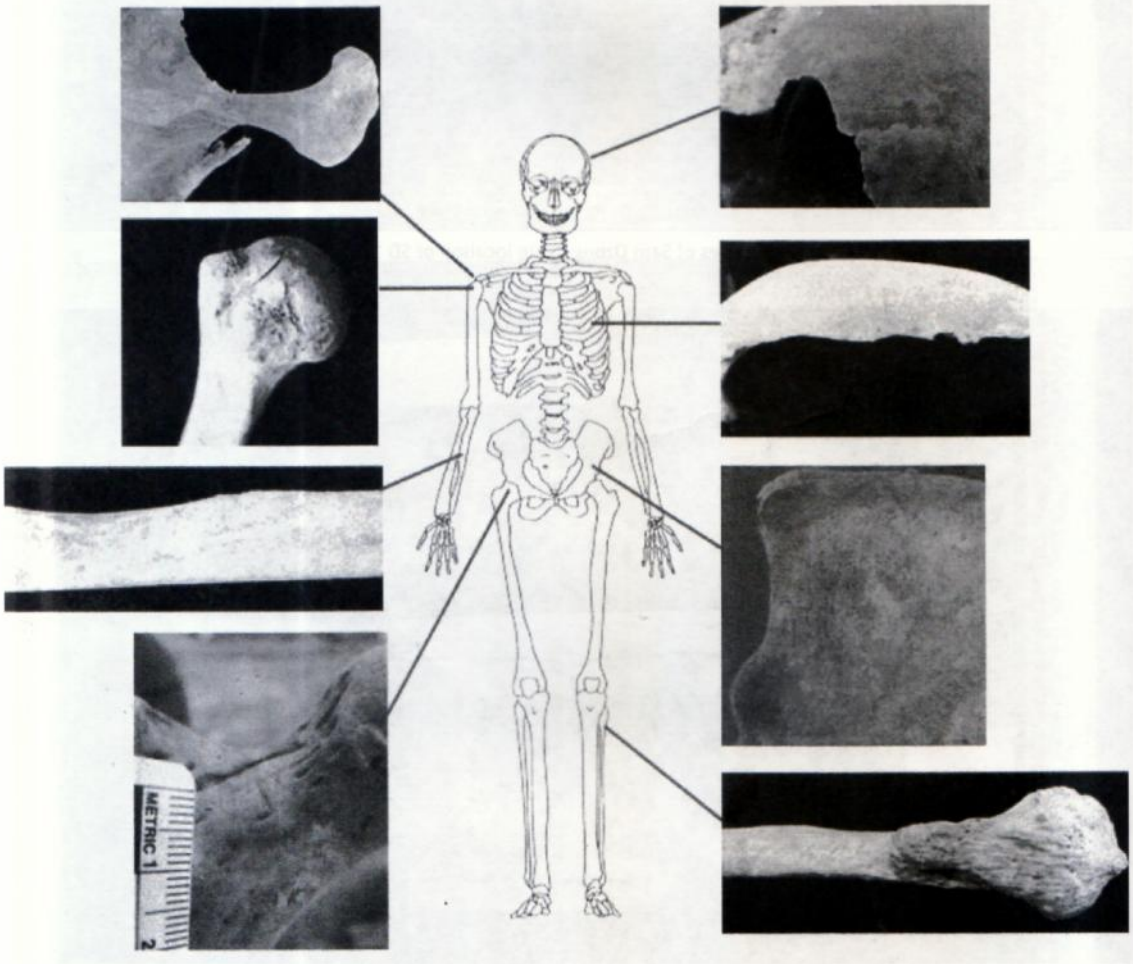

Figure 12. Cutmark on spine of the right scapula of an adult from the UM2010.8 burial

Figure 13. Shorter cutmarks found below the lesser trochanter of the right femur of the UM2010.5b female burial

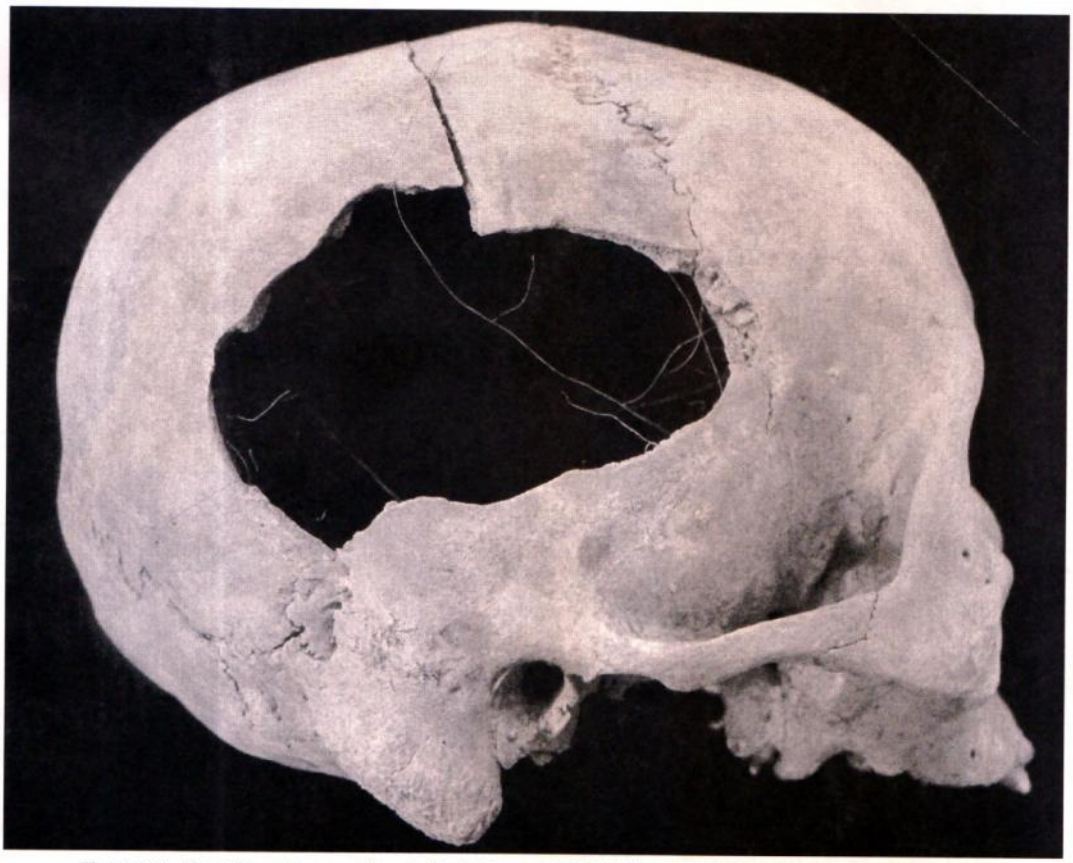

Figure 14. Blunt force trauma (healed) on the posterior left parietal of UM20210.5a male burial

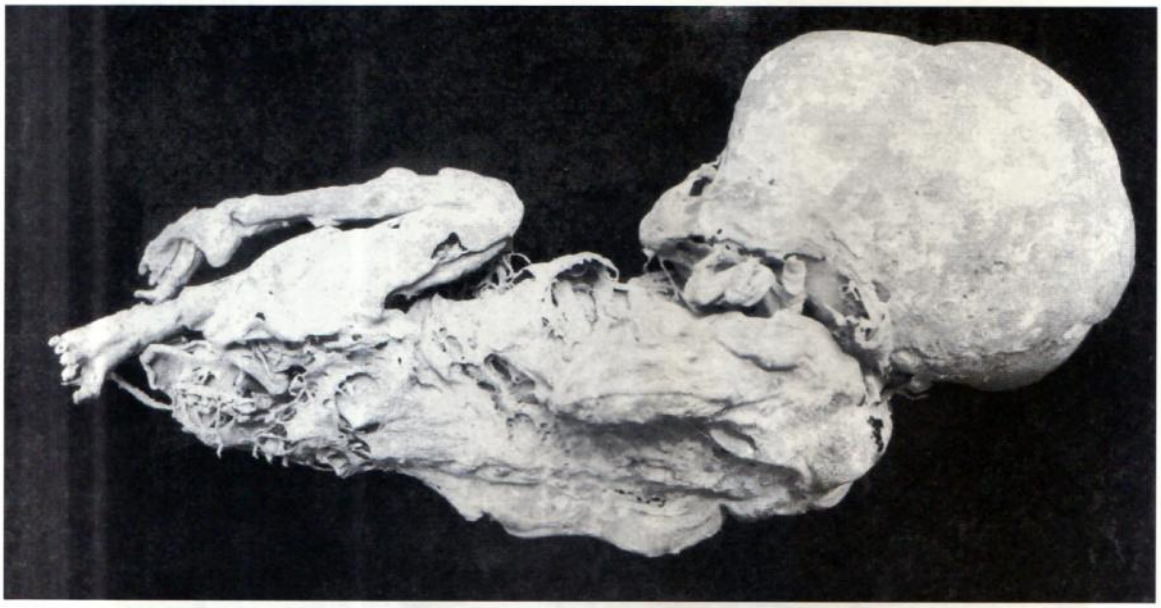

Figure 15. Endocranial sclerotic bone around the fracture in UM2010.10d

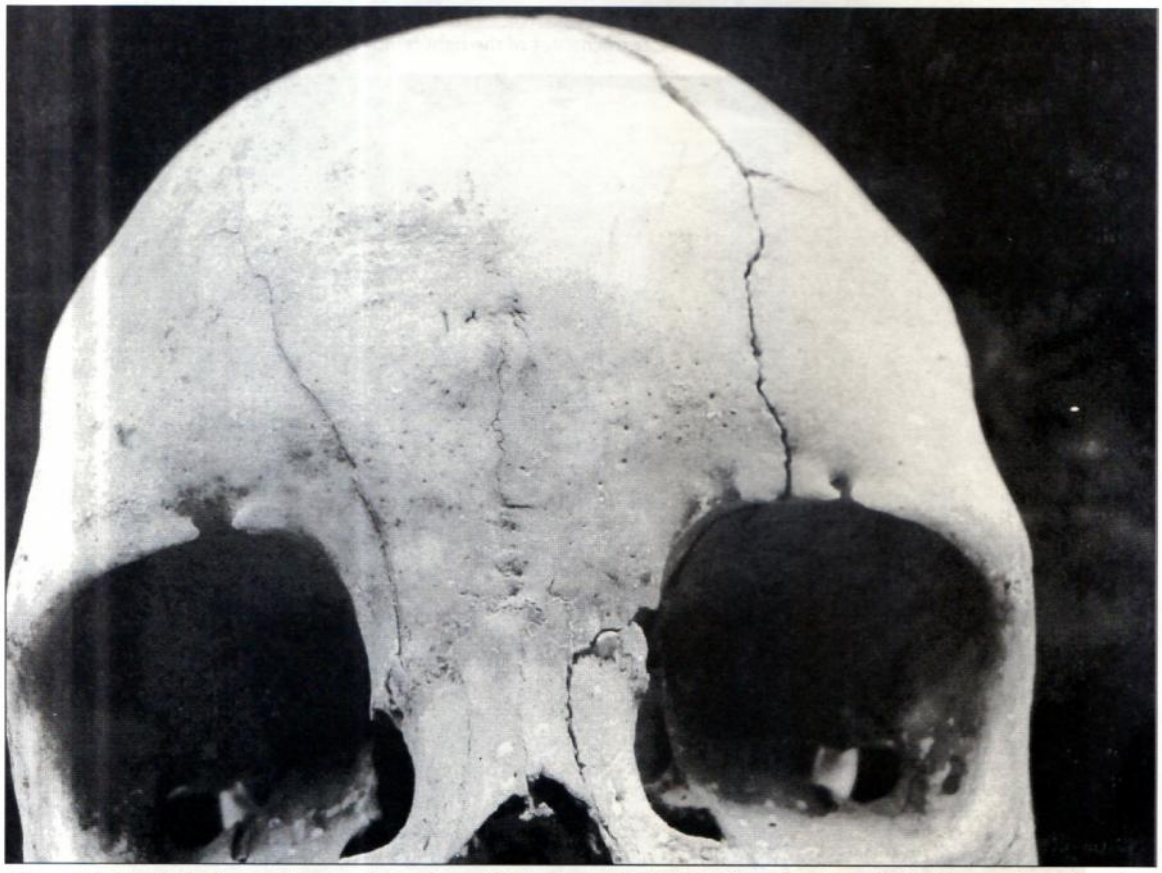

Figure 16. Cranial fracture on the superior surface of Mebrake burial 633-104 (Ind. 23), with radiating fracture lines from the bone of impact on the right frontal near bregma

ABOUT THE AUTHORS

Coningham, R.A.E., Schmidt, A. & Strickland, K.M.S	–	Research Scholar Department of Archaeology, Durham University, Durham, DH1 3LE, UK
Coningham, R.A.E., Schmidt, A. & Strickland, K.M.S	–	Research Scholar Department of Archaeology, Durham University, Durham, DH1 3LE, UK
Jacqueline T. Eng	–	Forensic Anthropologist Skydoor Foundation University of Mechigan, USA