MALAWI EARLIER-MIDDLE STONE AGE PROJECT

2013 Project Report

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I. INTRODUCTION

The Malawi Earlier-Middle Stone Age Project

The Malawi Earlier-Middle Stone Age Project (MEMSAP) is a cross-disciplinary project aimed at understanding changes in human technology, subsistence, and demography across the time period known as the Middle Stone Age (MSA – from ~ 280 – 30 thousand years ago [ka]). This is only possible with the establishment of long archaeological and palaeoclimatic sequences embedded within a well-understood chronometric framework. Because individual sites do not cover this entire time period, MEMSAP uses a landscape approach to build a long sequence from different sites present within the exceptional archaeological record of northern Malawi. Ultimately, this sequence will be used to achieve four project goals:

Goal 1: Characterise significant attributes of technological behaviour throughout the entire MSA;

Goal 2: Identify important changes in landscape and resource use (specifically lithic raw materials and water sources);

Goal 3: Link human demographics to climatic variability by identifying if populations moved during periods of harsh climate; and

Goal 4: Test the following six hypotheses about the timing and mechanisms of behavioural/demographic change:

- **H1**: There are detectable differences in stone tool manufacturing techniques over time in a single locality.
- **H2**: Discernible behavioural change took place across the entire Middle Stone Age (rather than only at the end).
- **H3**: Technological change occurred in concert with changed conditions for the availability of lithic raw material resources (owing to tectonic and geomorphic forcing of landscape change).
- **H4**: Behavioural change was most rapid and punctuated during periods of harsh climate conditions.
**Summary of MEMSAP Activities to Date**

Most project activities have taken place near the town of Karonga (Figure 1). To date these activities have included the emplacement of 19 archaeological excavations, ranging in size from 50 x 50cm at the smallest to 32 x 2m at the largest (with an average size of 9m²). Kafulu (1983) found that the landscape of Karonga does not erode into tall exposures suitable for field mapping of buried stratigraphic units. Therefore, the archaeology cannot be contextualised within the greater landscape without accompanying geological trenches. To this end, 27 geological trenches have been emplaced both on- and off-site in order to understand the geological/depositional context of the archaeological finds. An additional 23 test pits have been excavated archaeologically and described/sampled geologically to serve both archaeological and geological purposes. An overview of how these activities have proceeded to date is provided in this section, with details of the 2013 work comprising the remainder of the report.

In 2009 a pilot survey in Karonga identified key areas for further research (Thompson et al. 2009), including the 'elephant butchery site' at Mwanganda's Village reported by Clark and Haynes (1970) and the Airport Site near Chaminade (Thompson et al. 2012a). The first full MEMSAP season took place in July/August 2010 (Thompson et al. 2011). Excavations during this season at the Airport Site recovered over 2500 sharp-edged artefacts from at least two different depositional contexts: an iron pan stratified between two sandy units and the top of a buried cobble horizon. The most current presentation of data from the Airport Site can be found in Thompson et al. (2012a). The artefacts that could not be studied over the course of the 2010 field season were
exported temporarily to the University of Cape Town, where they were studied by Dr Alex Mackay. They were returned to Malawi in 2011.

In 2010 test excavations were undertaken at the northern site of Kafula Ridge West (in the Lufira river catchment) and at Mwanganda’s Village (Thompson et al. 2011). The

**Figure 1** Location of study area showing the distribution of MEMSAP excavations to date. Lake Malawi lies to the right and the Karonga District border is the white line to the left. Image from Google Earth.
small (1 x 1m) excavation at Kafula Ridge West was also a salvage excavation as several conjoining artefacts were found eroding from a modern channel cut; these were later dated to approximately 9 ka, and the surrounding geological context was revealed to be a saprolite blanketed by colluvial remnants of Dinosaur Beds. Although MSA materials were abundant in the deposits, none were likely to have been in situ. Later surficial deposits such as the example at Kafula Ridge West were shown to retain substantial spatial integrity.

At Mwanganda’s Village the fossil- and artefact-bearing palaeosol unit reported by Clark and Haynes (1970) and Kafulu (1990) was not relocated in 2010, but a test pit on a higher terrace ca. 60m to the southeast revealed a lithic assemblage buried under 1.5m of overburden (Area I). This discovery stimulated excavations in 2011 that resulted in the recovery and analysis of a larger sample of artefacts that were found to represent an in situ accumulation of terminal MSA stone artefacts (Thompson et al. 2012b). Many of these artefacts were found to conjoin, leading to need for a final expansion of this excavation in 2012 to understand the spatial distribution of conjoining artefacts at the site. The artefacts from the Mwanganda Area I assemblage were temporarily exported to the University of Queensland for refitting analysis, then returned to Malawi in 2013 after this study was completed. Some of these data were published in 2013 (Thompson et al. 2013b) and more results are currently in preparation.

In 2011 excavations at Mwanganda’s Village identified the palaeosol described by Clark and Haynes (1970) that contained a partial elephant skeleton in association with MSA stone artefacts. The 2011 investigations (Area III) also showed that subsequent work by Kafulu (1990) had not been conducted directly adjacent to the original Clark and Haynes elephant excavation. Instead, Kafulu’s geological work had been set adjacent to a different excavation by Clark and Haynes and the north arrow had been rotated on the map. Once this was understood, new geological and archaeological goals for interpreting the site of Mwanganda’s Village were established. The results of this spatial analysis were published in 2013 (Thompson et al. 2013b), along with new geoarchaeological interpretations of the site (Wright et al. 2014).
In 2011 two sites in the Chaminade area near the Karonga airport were also excavated (Thompson et al. 2012b). The first, Chaminade I, yielded a small artefact assemblage upon which analysis was initiated in 2012. A manuscript is currently in preparation that describes the site, its age, and its geological context (also detailed in this report). The second site, Chaminade II, was the largest excavation to yet be undertaken by MEMSAP. It was established as a long trench in order to understand subsurface variability in artefacts and their depositional contexts in deposits that are analogous to the badly eroded Chaminade badlands area several metres to the west. Fourteen geological trenches in the Chaminade area were also emplaced, described, and sampled in 2011. A concurrent survey was undertaken by Mr Andrew Zipkin for possible ochre sources in the Karonga area. Results from non-artefactual ochre samples have recently been published from this study (Zipkin et al. 2014, in press).

The first 50 m² of Chaminade II was excavated as an “off-season” led by staff from the Malawi Department of Antiquities and following the main 2011 fieldwork. The long trench was prepared for hand excavation first by a mechanical excavator in order to access deeply buried MSA deposits. The result was a 2 x 25m excavation down to a maximum depth of ca. 4m (2m below the level at which the mechanical excavator ceased digging). Artefact analysis primarily took place in Karonga in 2012 by Ms Sheila Nightingale. The remaining un-studied artefacts were temporarily exported to the City University of New York in 2013 and they will be returned to Malawi in 2014.

2012 was a year of peak field and analytical activity for MEMSAP. The main goals of this season were to complete excavation at Mwanganda’s Village and at Chaminade II, as well as to understand the greater distribution of sites around Karonga and their larger regional context of alluvial fan formation (Thompson et al. 2013a). At Mwanganda’s Village excavation was expanded at both Area I (to a maximum of 25 m²) and at Area III (to a maximum of 30 m²). The artefacts recovered from Area I were temporarily exported to the University of Queensland to join those from 2011 for refitting analysis, and were returned to Malawi with the rest of the assemblage in 2013, where they are currently fully labelled and organised by raw material type. Analysis of all artefacts from Mwanganda’s Village was completed in 2013, as detailed in this report. These
results are in preparation for publication, following from the recent publication detailing new interpretations of the geoarchaeology of the site (Wright et al. 2014).

At Chaminade II the trench was extended to 32m long (from 25m at the end of the 2011 off-season). A deep sondage at the southern end of the trench was excavated to nearly 6m and sampled for cosmogenic nuclide dating. Two additional cosmogenic nuclide burial profiles were sampled from geological trenches in river catchments south of Karonga (Ruasho and Wovwe). Ten geological trenches were excavated in these and other southern catchments to obtain data on the timing and processes of alluvial fan formation in the Chitimwe Beds.

Extensive surface survey was also undertaken in 2012. Five days were devoted to survey by a five-person team around Karonga to identify the distribution of sites and different artefact types. This resulted in the emplacement of 21 test pits and the discovery of a site (CS-70) nicknamed “Bruce” that was subjected to three small (1 x 2m) excavations in 2012. These were excavated more deeply, sampled, and described more fully in 2013, and those preliminary results are reported here. Also in 2012, twenty-eight linear km in the North Rukuru, Ruasho, and Remero catchments were surveyed to ascertain the locations of different types of stone artefacts and their degree of reduction relative to raw materials (e.g. cobbles). These artefacts were described at their find spots and not collected, as reported in a manuscript that has recently been accepted for publication (Thompson et al. 2014, in press). An extension of this survey work was done in 2013, and is reported here.

A second “off-season” excavation was also conducted in 2012, at the site of Chaminade West (also called Chaminade III). The location was selected based on a continuous sequence of MSA and LSA artefacts in sharp condition that had been discovered at the site of Test Pit 7. The site was excavated down to 4m with a series of safety steps. It was found that a large LSA assemblage with a subsurface slope to the south overlay a series of sands with MSA artefacts deposited in a laminar fashion. Below this, the site was archaeologically sterile and did not immediately match the stratigraphy in Test Pit 7. As a result, an extension trench was excavated in 2013 and is reported here. All
excavations were fully backfilled by the end of the 2012 field seasons. Those for which further study was designated in 2013 (e.g. CHA-III and Bruce) were packed with sandbags and black plastic, and then backfilled.

**Summary of Project Outputs to Date**

**Publications**


**Conference Presentations and Posters**


11) Thompson, J.C., Simfukwe, H., Malijani, O., Chinula, M., Welling, M., and Gomani-Chindebvu, E. (2012). “Data collection, information transfer, and digital site visualisation as tools for remote project supervision: Case study from Middle Stone Age deposits of northern Malawi”. Paper accepted to the High-Tech Heritage conference, Amherst, Massachusetts, USA (not delivered).


Outreach

1) “MEMSAP: Dispatches from the Field” is a blog maintained at [http://www.memsap.org](http://www.memsap.org)


3) Zipkin, A.M. (March 2012). “Material Symbolism and Ochre Exploitation in Middle Stone Age East-Central Africa”. Public lecture given at Memorial University of Newfoundland, St. John’s, Newfoundland, Canada.


6) Thompson, J.C. (June 2010). “New investigations into the Middle Stone Age of Malawi”. Seminar given at the University of the Witwatersrand, Johannesburg, South Africa.

7) Thompson, J.C. (April 2010). “New investigations into the Middle Stone Age of Malawi”. Seminar given at the Stone Age Institute, Bloomington, Indiana.

Project Reports


Education and Training

MEMSAP has hosted a field school in Karonga for the Catholic University of Malawi since 2010 and The University of Queensland since 2011.

MEMSAP has provided essential training for domestic and foreign students, professionals, and community members through work experience and education. Dr Jessica Thompson and Dr David Wright have provided letters of strong support for Mr Oris Malijani, who has worked with MEMSAP since 2010, and who recently received his choice of two full foreign scholarships to complete a Master's degree in either Heritage Management or Archaeological Science abroad in 2013/2014.
Attention is also brought to the richness of the archaeological record in northern Malawi via the project’s Facebook website:

http://www.facebook.com/#!/pages/Malawi-Earlier-Middle-Stone-Age-Project/257887127623607

An online blog called “Dispatches from the Field” has also been maintained for the last two years at http://memsap.org/.

Summary of 2013 Activities

This report updates the information provided in previous field reports (Thompson et al. 2009, Thompson et al. 2011, Thompson et al. 2012b, Thompson et al. 2013a). MEMSAP activities in 2013 fell into seven major categories, each with a specific goal (Table 1). This report describes each of these activities in turn.

Table 1 List of the goals for 2013 and activities described in this report that were undertaken to meet these goals.

<table>
<thead>
<tr>
<th>Item</th>
<th>Goal</th>
<th>Activity</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Obtain greater chronological control and geoarchaeological context for two existing sites (CHA-III and BRU)</td>
<td>Re-open backfilled trenches to study profiles and take OSL and micromorphology samples, and excavate a step-trench on the hill to the east of CHA-III</td>
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<tr>
<td>2</td>
<td>Determine the relationship between the Test Pit 7 from 2012 regular season and the Chaminade III site from the 2012 off-season</td>
<td>Extend a trench from CHA-III toward TP7</td>
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<tr>
<td>3</td>
<td>Finalise sample sizes for artefact assemblages at BRU</td>
<td>Completion of excavation of three existing Areas at BRU</td>
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<tr>
<td>4</td>
<td>Assess how core technology, lithic raw material, and ochre sources are distributed across the greater landscape.</td>
<td>Transect surveys of major river catchments draining across the Chitimwe Beds.</td>
</tr>
<tr>
<td>5</td>
<td>Prepare for curation of all assemblages recovered to date.</td>
<td>Laboratory work to label and curate artefacts, sort wet-sieved residue, and process sediment samples.</td>
</tr>
<tr>
<td>6</td>
<td>Continue analysis of stone artefacts and samples and move the results towards publication.</td>
<td>Continued analysis of stone artefacts and samples.</td>
</tr>
<tr>
<td>7</td>
<td>Prepare results to date for publication</td>
<td>Manuscripts prepared and submitted to journals.</td>
</tr>
</tbody>
</table>
II. CONTEXT OF RESEARCH

Theoretical Background

The theoretical impetus for the development of MEMSAP was drawn from debates about understanding the origins and dispersal of anatomically and behaviourally modern humans (d’Errico and Stringer 2011). For archaeologists, it has not been well-understood when, at what pace, and why key behavioural traits first arose in our species (Chase and Dibble 1990, McBrearty and Brooks 2000, Mellars 2007, Henshilwood and Marean 2003, Gamble 1994, Klein 2008). However, recent improvements to the empirical record in eastern and southern Africa have shown that many of the important changes leading to the modern behavioural suite occurred in Africa during the Middle Stone Age (MSA). The MSA was a time period that ranged between ca. 30 – 280 thousand years ago [ka] in east Africa, but possibly started as early as ca. 500 ka in southern Africa (Tryon et al. 2005, Tryon and McBrearty 2002, Tryon and McBrearty 2006, Porat et al. 2010, Wilkins et al. 2012). It was also a time that witnessed a series of severe climatic fluctuations, which likely demanded behavioural and/or demographic changes in MSA populations (Basell 2008). In Malawi the climatic story has recently become much better-understood, and shows that a series of “megadroughts” swept through central Africa during the Late Pleistocene – undoubtedly impacting local populations (Cohen et al. 2007, Scholz et al. 2011, Scholz et al. 2007). This background has been thoroughly described in previous reports, which also detail how these issues relate to the work reported here (Thompson 2010, Thompson et al. 2011, Thompson et al. 2012b, Thompson et al. 2013a).

Research conducted under MEMSAP makes two major contributions to modern human origins research. First, it provides a rare opportunity to test two major competing models of the rate of behavioural change during the MSA that cannot be falsified with shorter sequences from other investigated parts of Africa. Second, it allows the first direct tests of the climate-driven model for central African megadroughts and their impact on MSA populations. These contributions are all the more significant because they will be derived from the central African record, which can bridge existing – and more abundant – knowledge from the eastern and southern African records.
Malawi Rift Geologic and Tectonic Context

The archaeological record of Karonga cannot be understood without placing it within its greater depositional context. Human behaviour and site distributions are structured by the landscapes upon which they occur. Archaeologically visible resources such as water sources and stone to make tools are not evenly distributed across the landscape. Furthermore, northern Malawi contains formidable geophysical barriers – such as Lake Malawi to the east and a series of highlands to the west – that present differential foraging opportunities which must be taken into account by mobile hunter-gatherer groups. Second, since the time of their initial deposition, MSA sites have likely been affected by numerous post-depositional processes. An understanding of the geological and geomorphic processes in the area is essential for understanding not only where sites were likely to have been first created, but also where and how they may have subsequently become either altered or preserved.

Located on the border of Malawi and Tanzania and to the south of Lake Tanganyika, Lake Malawi is segmented into three half-graben segments of alternating polarity (Ebinger et al. 1987, Rosendahl 1987). Each ~50 km wide half-graben is bounded by a 100 km-scale steeply dipping normal fault (Wheeler and Rosendahl 1994, Ring 1994). The focus of MEMSAP is on the northernmost basin of Lake Malawi, the NW-SE-trending Tukuyu-Karonga half-graben, which is separated from the central, west-tilted Nkhata-Mbamba basin by an accommodation zone to the south and bounded by the 120km long Livingstone fault to the east. There is a marked east-west asymmetry to the deformation along the Livingstone fault. Whereas a significant amount of crustal deformation is present on the west side of the hangingwall in the form of numerous synthetic intrabasinal normal faults, the footwall to the east remains largely undeformed.

Rifting in this section of the East African Rift System (EARS) is likely to have commenced at 12-8 Ma with throw primarily accommodated on the border fault. Synthetic intrabasinal faults developed later in each half-graben, breaking up the footwall both on and offshore (Mortimer, et al. 2007; Biggs et al., 2010). Extension and subsidence of this basin create the accommodation space required for sediment aggradation. Measurable extensional activity today is derived from GPS measurements,
which range from 3.7 to 3.8 mm/yr (Stamps et al. 2008). Maximum subsidence rates have been calculated at 0.5-1mm/yr in the western branch of the EARS (Einsele 1996), and average sedimentation rates in the Lake Malawi basin are estimated at ~1mm/yr (Johnson et al. 2002). The latter rates are less reliable for the deeper sections of the lake core and basin, but are likely representative of average rates at least back to the Pleistocene. Still-active intrabasinal faults on the hangingwall, many of which lie on the western margin of Lake Malawi, also influence sedimentation patterns within the basin (Biggs et al. 2010, Fagereng 2013).

Depositional and Palaeoenvironmental Context

On the steep, eastern margin of the basin, high slope and local relief characterise the bare-bedrock, mountainous landscape. Within the eastern depths of the lake, thick sedimentary sections indicate a total of ~6 km throw (Ebinger et al. 1999) along the Livingstone Fault, creating a ~2 km-high escarpment at the front of the Livingstone Mountains. The western hangingwall landscape is comprised of mostly gently-sloping and incised alluvial surfaces. These sediments grade down to the half-graben fill beneath Lake Malawi, creating a 5-10 km wide coastal plain of Quaternary sediments. These sediments include the Middle-Late Pleistocene Chitimwe Beds, which outcrop along this stretch in areas of up to 20km² (Figure 2), unconformably overlying Pliocene lacustrine/near-shore sediments known as the Chiwondo Beds (Kaufulu et al. 1981). The Chitimwe Beds are also a rich source of Stone Age artefacts, a preponderance of which are typologically assigned to the Middle Stone Age (Thompson et al. 2011, Thompson et al. 2012b, Thompson et al. 2014, in press, Clark 1966).

The abundant MSA record of northern Malawi received its first detailed attention in the 1960s from J. Desmond Clark (Clark 1966, Clark et al. 1966, Clark et al. 1970, Clark and Haynes 1970). The exposures reported by Clark near the Chaminade Secondary School in Karonga are representative of a subset of MSA deposits that are rich in both lithic raw materials in the form of cobbles and artefacts manufactured on those cobbles (Clark 1966, Clark 1968, Clark et al. 1967, Clark et al. 1966, Clark 1972, Clark and Haynes 1970). This phenomenal abundance of artefacts means that large, meaningful samples can be excavated to compare human adaptations across time and space.
Accompanying this outstanding MSA record is one of the longest and most detailed terrestrial palaeoclimate records in Africa, which was derived from cores taken from sediments in the northern basin of Lake Malawi (Cohen et al. 2007, Scholz et al. 2007, Scholz et al. 2011). These records show that several periods of ‘megadrought’ occurred in central Africa between ca. 135 – 75 ka, during which time water volumes in Lake Malawi were reduced by as much as 95% (Brown et al. 2007, Cohen et al. 2007, Scholz et al. 2007, Stone et al. 2011) and exposing human populations to significant periods of resource change (Figure 2). In addition to the impact on humans, major changes in base level at Lake Malawi would have initiated a landscape response, affecting the deposition and subsequent alteration of MSA sites entrained within them.
III. SURVEY

Overview

Mobility is a key adaptive strategy among modern foragers in arid regions, who cope with the effects of drought through “drought escape” (abandonment of affected areas) and “drought evasion” (population fragmentation into areas with reliable surface water) (Gould 1991). The stone artefact record offers durable evidence of such human mobility strategies that can inform about decision-making, land use, and the presence or absence of human populations (Dietl et al. 2005, Barut 1994, McCall 2007). This is especially relevant in areas such as northern Malawi, where “megadrought” periods imposed significant changes in resource configuration on people living there in the Late Pleistocene. The abundance of surface artefacts in Karonga, especially within and around the Chitimwe Beds, offers a unique opportunity to provide the first regional-scale analysis of MSA land use in central Africa by testing hypotheses about how MSA populations adjusted foraging patterns in response to periods of resource change such as drought. In order to achieve these goals, survey was performed in 2013 of a series of major river catchments in Karonga. This survey built on pilot fieldwork from 2012 (Thompson et al. 2014, in press), where patterning was identified with respect to different types of stone raw material availability and their use by MSA people. Specifically, that work found that there are important differences in what types of stone and other resources are available between the north and south of the Karonga District. It is this dichotomy that promises to offer significant and novel insights into MSA land use strategies and response to fluctuating resources over time, and thus the survey was designed to sample parts of both areas.

Surveys were conducted by Oris Malijani, Victor de Moor, Davie Simengwa, and James Flittner. The 2013 surveys focussed on two features. Firstly, the analysis focussed on cores, the single most informative type of artefact for analysing stone tool production strategies. Secondly, analysis also included unmodified cobbles, the raw stone material sources mainly in use in the area during the Middle Stone Age. Stone artefacts were not collected, but were recorded and photographed at their find spots.
Rationale and Hypotheses

The Chitimwe Beds lie within a series of river catchments bounded to the west by Highlands and the east by Lake Malawi. This “closed” landscape and the uneven distribution of stone, water, and vegetation resources in Karonga allows for the testing of novel hypotheses about patterns of MSA land use at scales most relevant to past mobile foragers. All rivers drain east and are dominated by three large catchments that define the northern landscape (Figure 3). Their lower reaches contain quartzite cobbles of high quality for stone tool manufacture (Stephens 1966). Thus, foragers moving east-west would have crossed diverse environmental zones and resource patches along a topographic gradient. Although maintaining regular access to fresh water, they would have needed to visit the lower catchments to obtain the best toolstone.

![Figure 3 River catchments in the Karonga District. Note the very long, extensive catchments of the northern rivers (Songwe, Lufira, and North Rukuru) compared to the short catchments of the southern rivers. Stream order follows Strahler (1992). Precipitation data are from Hijmans et al. (2005).](image-url)

In contrast, the southern landscape comprises many smaller catchments where the majority of cobbles are small, medium-quality quartz (Thompson et al. 2014, in press). South of Karonga town rainfall plateau at ca. 1000 mm and the highly seasonal
conditions are semi-arid to arid most of the year. In the north, rainfall nearly doubles to 1800 mm and vegetation is lusher year round (Hijmans et al. 2005) (Figure 3, inset). Foragers moving from north to south would have experienced less topographically-controlled environmental variability but longer distances between surface water, increasing distance from the best stone materials, and increasing aridity. These effects would have been exaggerated during periods of drought.

Blome et al. (Blome et al. 2012) suggest that early human populations in tropical Africa adapted to major climatic changes by moving and reconfiguring rather than completely depopulating large areas. Both have been observed to be strategies employed by modern foragers and recent archaeological populations in arid environments (Gould 1991, Veth 2008). Areas of high topographic variability (northern Karonga) are impacted more slowly by climate change than low-lying and arid areas (southern Karonga) because topographically diverse regions have a slow ‘velocity of temperature change’ along their gradients (Loarie et al. 2009). How humans responded to this resource differential can be examined for the MSA of Karonga within the theoretical frameworks of provisioning and risk mitigation, which both draw from optimal foraging theory (Thompson et al. 2014, in press, Bousman and Cruz-Uribe 1998).

We hypothesise that the orographically-controlled and seasonal aridity of the smaller southern catchments would have translated to the riskiest (most uncertain) conditions in Karonga. In contrast, the northern catchments would have had the highest potential for the persistence of refugia during extreme arid periods (Basell 2008), as the area they cover receives greater precipitation, contains higher-quality toolstone, has less ephemeral surface water, and enjoys high topographic (and therefore resource) variation. Therefore, drought evasion strategies should have dominated the southern catchments, overprinted by periods of drought escape. In the north, there should be more continuous records of human occupation and evidence of less long-range mobility. Test implications for the southern catchments relative to the northern catchments are:

1) there should be more catchment-specific use of lithic resources, expressed through raw material prevalence relative to local availability; 2) there should be greater variation in artefact curation and/or cortex ratio values, because frequent long linear movements – typical of open and unpredictable settings – will create imbalances in
cortex proportions (Douglass et al. 2008); 3) there should be periods where little archaeological material is deposited; 4) there should be fewer sites per area of preserved deposit and fewer artefacts per site; 5) there should be less evidence for group aggregation in the form of ochre use, diverse stone artefact forms, and diverse raw materials; and 6) there should be more investment in technological complexity (Hiscock 1994), increased flaking efficiency (Mackay 2008), and tool curation as buffers to subsistence and movement uncertainty - especially during periods of drought (Torrence 1989).

**Survey Methods**

This aspect of MEMSAP work rejects the notion of “site”-based analysis (Dunnell 1992), in favour of understanding palimpsests of human behaviour at the landscape scale (Fanning et al. 2009, Fanning et al. 2008, Holdaway and Fanning 2008). Large-scale surveys are required since surface cores and cobbles are analysed instead of large assemblages of *in situ* artefacts. This approach is applied because abundant sources of lithic raw materials, such as river or river terrace cobbles, are available on the entire landscape. In addition, geomorphologic aspects of the survey areas and taphonomic processes on the artefacts are taken into account. The objectives of the surveys are to investigate differences in raw material availability between the catchments and in relation to this, the possible variation in lithic reduction strategies within these catchments.

From 2011 onwards a system of analysis has been developed for studying and recording the artefacts on their find spots in the field during the surveys. Details of what attributes are recorded are provided in Thompson et al. (2014, in press). Hand-held GPS was used to record survey tracks. With the help of geological maps of the Karonga District – and geomorphologic research executed by MEMSAP geologists simultaneous with the surveys – possible Chitimwe exposures on the surface were investigated. To find the locations where the Chitimwe Beds and MSA artefacts are exposed on the surface, geological maps of the study area were used, as well as information from recent geological surveys executed by MEMSAP geologists. Geological maps from the Malawi Ordnance Survey 1976 have been digitised into ArcGIS and can be displayed relative to survey tracks, as shown in Figure 4.
During the survey, angles of hill slopes were measured and estimated with the help of a clinometer. The percentage of visibility of the surface of the landform area was determined, as well as the percentage of exposure of the artefacts, which indicates what one would expect to see on the surface of the landform if the visibility was perfect. This system of archaeological surveying is based on the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales*. Care was taken record the artefact and transect attributes without straying from the transect itself. For example, if a large concentration of artefacts and cobbles was found, cores and artefacts outside the survey path were not recorded. In this way, comparisons could be made between characteristics of stone artefacts across the survey transect without adding undue bias from areas where artefacts were concentrated (2014, in press).
Results

In 2013 the emphasis was on extending survey into areas that were not covered in 2012 (Figure 5). These mainly included northern areas within the Songwe and Lufira catchments and southern areas within the Nyungwe and Wovwe catchments. In order to promote fuller coverage, the Wayi (in the central part of the Karonga District), and an area around Kayelekera (in the western part of the District) were also surveyed.

A total of 391 artefacts were recorded, along with a sample of 420 cobbles (Table 2). This is in addition to the sample of 280 cores and 501 cobbles recorded in 2012. One thing that is immediately apparent is the scarcity of Levallois flakes, the total lack of Levallois points, and the near-total lack of blades in the 2013 sample.
Table 2 Summary of artefacts and cobbles recorded in detail along survey tracks in 2013.

<table>
<thead>
<tr>
<th>Location</th>
<th>Cores</th>
<th>Cobbles</th>
<th>Levallois flakes</th>
<th>Levallois points</th>
<th>Blades</th>
</tr>
</thead>
<tbody>
<tr>
<td>Songwe (Ighembe Ridge)</td>
<td>34</td>
<td>40</td>
<td>5</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Songwe (Iponga)</td>
<td>93</td>
<td>90</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Lufira (Kafula Ridge)</td>
<td>64</td>
<td>60</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wayi (Lupele)</td>
<td>80</td>
<td>90</td>
<td>4</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Western N. R. (Kayelekera)</td>
<td>10</td>
<td>20</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wovwe</td>
<td>45</td>
<td>50</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wovwe (Uraha)</td>
<td>22</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nyungwe</td>
<td>43</td>
<td>50</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>391</strong></td>
<td><strong>420</strong></td>
<td><strong>16</strong></td>
<td><strong>0</strong></td>
<td><strong>3</strong></td>
</tr>
</tbody>
</table>

Another striking result from the 2013 data is its confirmation of a pattern found in 2012, where there was a shift in raw material use from the north of the District to the south. Specifically, quartz was rarely used north of the Remero, where normally ~90% of cores were produced on fine-quality quartzite. This occurred even where quartzite was uncommon in its abundance in local cobbles; for example in the Sadala region, where only ~50% of available cobbles are quartzite, ~90% of artefacts were made on this material. Raw material use did follow local trends in cobble abundances: where quartzite was more common, it was more commonly used, and where quartz was more common it was more commonly used. However, within these constraints there was clear preference for higher-quality stone. In the north this was quartzite, and in the south that preference became translated to a preference for higher-quality quartz than was commonly available in the north.

The 2013 surveys confirmed this pattern dramatically. When this dataset is combined with the 2012 data, a clear pattern of increasing use of quartz begins with the Remero catchment and gradually declines south into the Wowve (Figure 6). This trend is highly statistically significant, as shown by the Chi-squared test for trend ($X^2 = 249.641; df = 1; p < 0.0001$). However, there is also a clear change in raw material use between the Wayi, where quartzite is clearly still preferred, to the Remero, where approximately half of all cores were manufactured on quartz.
The cobble data also show a significant trend for increasing quartz from north to south ($X^2 = 73.903; df = 1; p < 0.0001$). However, this pattern is not as clear-cut (Figure 7).

**Figure 6** Graph showing the cores made on different raw materials in each of the survey catchments.

**Figure 7** Graph showing the cores made on different raw materials in each of the survey catchments.
There is a strong correlation between raw material use and raw material abundance ($Rs = 0.8601$, $p < 0.001$). However, there are also clear peaks in the presence of quartzite. These occur, as would be expected, in areas close to the Sungwa conglomerates that make up part of the Dinosaur Beds. However, today the Sungwa Beds are restricted to very small areas within the North Rukuru. The presence of many high-quality quartzites in the Lufira and southern part of the Songwe catchments suggest that these areas once contained Sungwa conglomerates that have now been completely reworked into stream beds and terraces.

Most analyses that have been performed to date have been based on 2012 survey data, which showed several patterns in terms of core abundances and clustering. Numbers of cores and where they were found along individual survey tracks are shown in Figure 8.

**Figure 8** Numbers of cores (white numbers) shown along survey tracks (white lines). Grey patches are Chitimwe Beds.
Based on 2012 survey data, it was found that cores are strongly clustered together (Figure 9), but that there does not appear to be any direct correlation between cores and cobble abundances. Nor was there any definitive restriction of cores to beds mapped as Chitimwe Beds – though this may be a consequence of the large scale at which the maps are available. Analysis of the 2013 survey data is currently underway.

**Figure 9** Minimum distance to next core using a radial distance function. The clear clustering of cores is shown by the large number that occur within 25m of another core.

**Discussion**

Significant progress has been made toward understanding human land-use and technological organisation in the Karonga district during the MSA. The limitations of our approach have been a lack of chronological control in an erosional landscape and the resulting palimpsest problem with its potential to obscure temporally-mediated spatial patterns. Our results display consistency in spite of this.
A surprising result of GIS analysis of the 2012 data was that although focus was placed on surveying exposures with Chitimwe Beds, these mapped deposits actually contained some of the lowest estimates of cores per m². In contrast, gneiss bedrock had much higher than expected estimates of core quantities. This is likely because most of the cores analysed from bedrock deposits were from the North Rukuru survey, in an area where mapped bedrock is blanketed with a veneer of cobbles in colluvial and proximal alluvial fan settings. Cores from this survey show relatively high amounts of weathering and are on average larger, further supporting the inference that they represent part of a lag deposit rather than cores manufactured after the fact on top of a lag deposit.

A possible explanation for the apparent paucity of cores in the surveyed Chitimwe Beds areas comes from geomorphic observations and archaeological excavations near the town of Karonga (Thompson et al. 2012a, Wright et al. 2014). These studies have established that although MSA artefacts occur abundantly within the Chitimwe Beds, they are commonly deeply buried in the upper sands. When they erode, they frequently do so from the shoulders of local topographic highs and lag onto a cobble/pebble base or into gullies incised into the softer underlying Pliocene lacustrine sediments of the Chiwondo Beds. This scenario is consistent with the survey data on exposure, as well as the artefacts themselves. Cores from the Chitimwe Beds had the smallest average degree of weathering and large numbers of them were recorded from the surface of the Chiwondo Beds in spite of the fact that they have never been found from within these Beds (Juwayeyi and Betzler 1995). These results show that cores found in the vicinity of Chitimwe Beds exposures, which occurs frequently, have not been moved severely due to natural processes.

We noted not only a strong tendency for cores to cluster together across the study area, but for those clusters to relate spatially to the distribution of cobbles. The composition of core assemblages was also highly sensitive to variability in the composition of lithic resources. The north-south trend of increasing quartz in cobbles was matched by an increasing prevalence of quartz in cores. While the spike in quartz core prevalence in the Remero exceeded expectation based on its frequency in cobbles, this excess is probably explained by the higher quality of quartz in the Remero.
Though neither distance to source nor core clustering influenced core reduction, measures of quality such as number of flaws, crystal size, and cobble shape were clearly important considerations to past knappers. The prevalence of cores made of fine grained rocks with few flaws far exceeded the prevalence of these characteristics in cobble assemblages. Thus, while knappers invariably made use of what was locally available at or near the source, they were selective in what they reduced and the extent to which they reduced it.

Cobble size and raw material changed from north to south, particularly when the Remero catchment is contrasted with the other areas. This pattern was further reinforced by results from the 2013 survey data. Raw material constraints here are reflected in the degree and manner of reduction. In the Remero, quartz was more common, cobble sizes were smaller, and the increase in quartz cobbles meant that raw materials in this area came in rounder packages, which offer fewer natural platforms and are more difficult to reduce than more angular materials. Correspondingly, cores were found to have fewer scars but more discoidal patterns of removal. These constraints led to apparent contrasts; for example, the Remero has the most cores where cortex has been completely removed, and yet has one of the smallest incidences of ten or more scar removals. This pattern of artefact reduction in accordance with its geological abundance and “package” size was also noted by Tryon et al. (2008) for the MSA of the Kapedo Tuffs of the northern Kenyan Rift.

However, another important finding that is not replicated in the Kapedo Tuff sites, or indeed in many other parts of Africa, was the lack of diversity in core form and reduction systems. This was reinforced by preliminary analysis of the 2013 data. The vast majority of cores we identified were characterised by a limited range of approaches to flake production in which single platforms were radially worked with or without hierarchy of hemispheres but with little or no emphasis on preferential products. We saw little clear evidence of blade production, point production or bipolar working. To this we might add that we observed no handaxes or bifaces of any other form, nor any retouched points or backed pieces. Clark et al. (1970) also found these forms to be exceedingly rare in the area.
Given the variability in core forms in other parts of Africa through the later Pleistocene, the consistency of core reduction in our sample seems quite remarkable. Does the lack of variability reflect a constricted age range for the land surfaces that were sampled? This seems unlikely given the dynamic nature of the local geomorphology and the range in preliminary ages obtained for formation of the alluvial fan system. Alternatively, does it genuinely reflect highly conservative approaches to knapping over extended periods, and if so, what are the underlying causes of this when contrasted with the diversity of technologies in surrounding regions? These questions can only be addressed through additional work in the region, but they point to the significance of our approach in considering the entire landscape rather than focusing on individual “sites”.

The data taken together suggest that cores were not transported, or at least that cores were transported neither often nor far. Our data are generally consistent with extremely ‘local’ behaviour, in which available cobbles were reduced to varying degrees but seldom heavily, and discarded at or near the source after the production of a small number of flakes. As we noted earlier in the paper, this possibility highlights the interpretive limitations associated with focussing strictly on cores, and leaves unclear the issue of whether the flakes themselves were transported or whether they too were discarded close to their point of manufacture – that is, whether the entire technological system was expedient or only that part of it (the cores) analysed in this study.

Past studies of modern human toolkits have shown that local material abundance generally mitigates against curation, where tools and kept and re-sharpened multiple times rather than discarded in favour of a fresh tool (Andrefsky 1994, Bamforth 1986). Furthermore, greater investment in complex tool production may be linked to increased risk in the environment, such that hunter-gatherers took steps to improve the reliability of their toolkits only under adverse environmental conditions (Bousman 1993, Collard et al. 2005, Read 2008, Torrence and Bailey 1983). Our data might thus simply reflect consistently weak incentives to transport tool-making potential in environments where the risk of failing to acquire resources was generally low. Hence, future work that will systematically test these hypotheses about risk will be essential for understanding how the local environment affected human technological behaviour.
Further Research

The tests of the hypotheses set out above will come from future assessment of flake transport in the area, from contrasts between assemblages from the cobble-rich alluvial fans studied here and those from the more cobble-depauperate landscapes in the adjacent highlands, and from association of the dated archaeological materials with the palaeoenvironmental record of the nearby Lake Malawi drill cores (Cohen et al. 2007, Scholz et al. 2011, Scholz et al. 2007). Though contemporaneity will be difficult to establish in all of these cases, it will be informative at least to test whether the consistency of technological form and organisation inferred for this study area hold true when the geographic coverage of the surveys has been expanded and more variable areas have been sampled.

Future work will therefore target three main practical outcomes:

1) Systematic linear survey directly up each catchment without restricting the transects to archaeologically promising areas. This will enable an unbiased view of where artefacts are actually preserved and what attributes they have when they are.

2) Systematic test-pitting along these survey lines to establish chronological control sequences for surface artefacts and also to determine where surface artefacts are found relative to buried archaeological deposits.

3) Full mapping and data collection across an area, rather than only linear survey. This work must take place in conjunction with detailed geomorphic maps rather than large-scale observations (Fanning et al. 2009, Fanning et al. 2008). Thus, future work should include new methods of aerial geomorphic mapping, such as stereoscopic photography with a kite or remote flyer and Structure from Motion software (Johnson et al. In review).
IV. EXCAVATION

Overview

There were four major excavation goals for the 2013 fieldwork: 1) Extend the 2012 excavations at Chaminade III (CHA-III) in order to understand its relationship to nearby Test Pit 7; 2) Emplace a step trench at CHA-IV, upslope of CHA-III, to ascertain the depth of the deposits extending above the site and the likelihood that the materials within the uppermost 0.5m have been displaced from farther upslope; and 3) Extend the depth of the 2012 excavations at Bruce Areas I, II, and III (BRU-I, BRU-II, BRU-III) to obtain a full depositional profile and buried artefact assemblage; and 4) Complete all profile description and sampling from these sites for pollen, phytoliths, micromorphology, OSL, and geoarchaeological interpretation. All of these goals were met, and an overview map of the locations of the sites excavated by MEMSAP in 2013 is given in Figure 10.

Figure 10 Locations of the main sites excavated in 2013 by MEMSAP and referred to in the text. Image from Google Earth.

Methods and Protocols

All site mapping, including piece-plotting, was conducted with a total station using a system based on the protocols developed by Marean et al. (2010). All samples and
artefacts identified in situ were piece-plotted with a Nikon Nivo 5” C-series total station running Survey Pro software to ensure precise spatial control of all excavated materials (McPherron et al. 2005), and orientations were taken on artefacts with a long axis to determine the nature of any post-depositional movement (McPherron 2005). Plotted finds were emplaced in resealable plastic bags with pre-printed, barcoded, archive-quality labels (Marean 2010). All sediments were passed through a 5mm sieve in order to recover artefacts that were not found during piece-plotting.

Where possible, a Bluetooth barcode scanner was used to associate each artefact number with its coordinates and point attributes as the artefact was mapped to reduce human transcription error. All context data (including sedimentary attributes, photographs, disturbances, and elevations) were recorded on standardised project context forms for which there are both digital and archive copies. Data were stored and analysed in an Access database and an interactive ArcGIS database that were updated daily. Because Dr Thompson was unable to personally participate in the fieldwork in 2013, data were e-mailed to her and processed daily in a similar fashion to the system that was undertaken during the off-seasons of 2011 and 2012.

Screen-washing was done for all excavated sediments and the residue was dried and sorted at the ‘dig house’, which also doubled as a field lab. Artefacts recovered in the screen were given specimen numbers in the lab using the same sequential numbering system as the piece-plotted artefacts. All 2013 excavations were backfilled using the residue that had passed through the screen. All laboratory procedures and site locations are detailed in Thompson et al. (2013a).

Excavation areas were defined for each site, and excavation proceeded by natural layers in 1 x 1m squares. Grid coordinates for the squares were based on a true coordinate grid but an alphanumerical system with letters increasing to the east and numbers increasing to the south was used. For example, the second square in the first row would be named B1. In some cases natural layers were subdivided into arbitrary 5cm spits except where artefacts had not been encountered in BRU-I for more than 0.5m. In this case, a spit thickness of 0.1m was adopted.
Each spit, layer, or feature was designated as a context and a complete record of the geological and archaeological characteristics of each context was kept on a Context Form and entered into a Microsoft Access database. A bulk sediment sample was taken of each context as it was opened, and kept as an archive. Where appropriate, sediment micromorphology, OSL, pollen, and phytolith samples were also taken from the profiles after excavation. Recording and total station protocols are provided in Thompson et al. (Thompson et al. 2012b).

Results

Chaminade III (36L 0595944mE 8900473mS)

Chaminade III (CHA-III) is located near a house surrounded by agricultural fields (Figure 11). The site was excavated in August 2012 (off-season) and re-opened for profile description and sample collection at the beginning of the 2013 field season (Thompson et al. 2013a). The deposits in this site are related to alluvial fan sedimentation.

The site was excavated in 2012 after discovery of a long sequence of artefacts in Test Pit 7 (TP7), which is approximately 10m to the northwest of the CHA-III excavation (note that Figure 36 from Thompson et al. [2013a] erroneously shows TP7 to the northeast rather than northwest).

Figure 11 Excavation at CHA-III: View north.

The CHA-III excavation was re-opened in 2013 to allow for profile drawing and sampling, and to better interpret the relationship of this excavation to the TP7 stratigraphy. A trench was also excavated that extended from the northern edge of CHA-III towards TP7 in order to better elucidate this relationship (Figure 12).
Preliminary OSL results from TP7 suggest that the cobble/gravel layer in which MSA artefacts are most abundant was emplaced after 63 ka (Figure 13). In 2013 this cobble layer was provisionally correlated with one of two gravel units (Unit 4 or Unit 6) in CHA-III. These units are at approximately the same depth at which no more artefacts were discovered in CHA-III. Alluvial fan deposits ca. 2m below this depth date to approximately 57 ka, with error ranges that overlap with the ca. 63 ka age from TP7. Therefore, if the TP7 cobble layer is the same depositional phenomenon as Unit 4 or Unit 6 in CHA-III, the sterile alluvial fan deposits at the base may represent an extremely short and rapid period of fan aggradation.

Figure 13 Artefacts by weight from TP7 (left) and section drawing of the west profile of the excavation at CHA-III (right). Almost no artefacts were recovered below 2m depth.
Two main concentrations of artefacts were noted in the 2012 excavation: one at the top and one between ca. 1 – 2m in depth. The same concentrations were noted in the 2013 extension trench. In both cases, diffuse artefacts overlie a buried sloping concentration of artefacts that are typologically Later Stone Age. Artefact concentrations then become diffuse again, and at approximately 1m in depth they take on a laminated character in which they are found deposited in relatively flat horizontal lines (Figure 14).

![Figure 14](image)

East view of the distributions of plotted finds excavated from CHA-III in 2012 and in the extension trench in 2013.

Although the deposits in CHA-III were sterile below ca. 2m, artefacts in the extension trench continued to the base of the excavation. Based on the position of the gravel layers in CHA-III, the extension, and TP7, it seems likely that there is a gravel layer that slopes subtly downward from south to north. MSA artefacts appear to begin within ca. 25cm of this layer (Figure 15), although the excavations in both TP7 and the extension trench became too deep to safely test this definitively in 2013.

Preliminary analysis of the plotted artefacts from square C4 provides initial information about the potential significance of the site. These results are provided in Section VII. Further information about site formation and the depositional sequence at CHA-III can be found in Section V and Appendix 1. However, it is worth noting that a preliminary OSL age from the top of the sequence at ca. 37 ka suggests that this entire sequence formed during a very rapid period of deposition during the Late Pleistocene. Tentatively, all occupation at this site appears to coincide with lowstand periods of Lake Malawi (Stone et al. 2011).
Figure 15 Position of plotted finds at CHA-III relative to geologic units in Figure 13.

Chaminade IV (36L 0595949mE 8900486mS)

The CHA-IV step trench was excavated on the slope to the east of the CHA-III excavation (Figure 16). Deposits on this hillslope contain abundant artefacts. If they are MSA, then this would mean that the MSA deposits at CHA-III had been potentially truncated and then overlain by LSA material that was either emplaced in situ after the truncation or slumped down onto the top of the truncated MSA deposits through processes such as slope wash. Alternatively, if the deposits upslope of CHA-III only contain LSA material they would post-date the CHA-III excavation, as would be expected based solely on elevation data.
A six-metre trench running upslope was excavated to a maximum depth of ca. 2m (Figure 17). As with CHA-III there was an initial concentration of artefacts at the top that was then followed by a diffuse zone and then a series of laminar deposits. Further details of site formation at CHA-IV are provided in Section V and Appendix 1.

**Figure 17** Configuration of the north profile of the final exposed section at CHA-IV with plotted finds mapped against the profile.

**Bruce (36L 0596563mE 8900830mS)**

In the 1960s and 1970s J.D. Clark and his students located several significant archaeological sites in Karonga. One of these, referred to by Clark as Chaminade 1A (Ch-1a), yielded an assemblage of over 25,000 stone artefacts and several specimens of worked ochre from an in situ deposit (Clark et al. 1970). However, the site was never absolutely dated, the ochre and stone artefact assemblages were never thoroughly analysed, and in the years since Clark’s excavation, the site’s exact location was lost. The discovery of the CS-70 (“Bruce”) site over the course of the 2012 Chaminade surveys may have resolved the final problem (Thompson et al. 2013a). A hand-annotated map of the Clark and Haynes excavations was obtained and scanned from C.V. Haynes at the University of Arizona, georectified into the MEMSAP GIS, and then compared against
other data held in that GIS (e.g. MEMSAP excavations, geologic units, etc.). When MEMSAP test pits are compared against the locations of the original Clark excavations, it was noted that several similar localities have been marked as deserving investigation by both groups (Figure 18).

Figure 18 Digitised map of hand-annotated sites from materials held by C.V. Haynes (green stars) superimposed on digitised geological maps (Plc is the Chitimwe Beds) and with MEMSAP sites identified with yellow circles (CS stands for “Chaminade Survey” and refers to Test Pits excavated in 2012). Green stars with blue circles around them represent Clark’s sites with a 100m buffer around them to compensate for the lack of precision in older maps. Note the proximity of Clark’s Ch-1a to our Bruce, Ch-3 to our TP8, and Ch-2 to our TP12.

The Bruce site surface exhibited a depression suggestive of a previous excavation, with mounds that may represent spoil heaps from the 1965 excavations and large numbers of surface artefacts and some modified ochre pieces that generally match the original assemblage description. Images of the site during excavation in 1965 (provided from the archives at the Stone Age Institute by K. Schick and N. Toth) show a skyline that compares favourably to the modern skyline, showing that it is overlooking the North Rukuru from the correct perspective. Finally, after showing the site to W. Magumbwa
from the Cultural and Museum Centre Karonga in 2012, he confirmed that he used to shortcut through this place as a boy while excavations were ongoing.

In 2013 excavations continued more deeply in three 1 x 2m Areas (Area I, Area II, and Area III), with Area I extended to a 1 x 3m trench. Latrine pits newly dug for a nearby house had been mapped and sampled in 2012, and two test pits dug in 2012 (Test Pit 20 and Test Pit 21) were re-exhumed and sampled in 2013 (Figure 19). Across the site the majority of excavated finds were located within the lower ~20cm of an upper alluvial unit. These upper deposits have been extensively altered by agriculture, water erosion, and dumping.

A large surface depression scattered with thousands of artefacts is suggestive of the location of the original 1965 excavations. The 1965 excavation plan was digitised onto the depression and oriented as per the archival photographs and does in fact match up well to the depression (Figure 20). GIS was useful at the Bruce site for

Figure 19 Google Earth satellite image (October 2012) showing locations of excavations, interpolated elevations, excavation Areas (yellow), Test Pits (green), surface collection area (orange), and latrine pits (purple). The spring is indicated in blue.

Figure 20 Potential location of the original 1965 excavations relative to MEMSAP excavations.
palaeosurface modelling. Elevation points were taken at the top of fluvial facies exposed in test pit and excavation profiles, and then used to interpolate a surface representing those buried facies across the site. This was useful for illustrating the thickness of artefact-bearing alluvium across a profile (Figure 21, profile taken across the white line shown in Figure 19). In addition to predicting the depths at which artefacts should be found, this is useful for understanding the potential for postdepositional movement of artefacts along a slope. The data also allow linkage to more regional-scale depositional processes by reconstructing the palaeoslope of more energetic facies of the Chitimwe Beds where they grade down to the North Rukuru River.

Figure 21 85m profile along the white line in Figure 19 showing sample intervals with surface and subsurface topography.

Details of the geoarchaeological context of the three Bruce excavations can be found in Section V and Appendix 1. A useful way to examine site formation processes is to map plotted finds against georectified sediment profiles to see where concentrations lie. At the three Bruce excavation Areas this has revealed some consistent patterning in the uppermost units.

At Area II, the east profile shows a mound of overlying deposit that has been preserved by a tree stump in the face of the serious erosion that has scoured the area to the east. Within this profile, there is a clear concentration of artefacts at and immediately above
the level of a pebble stringer that was found across the excavation. In this excavation the stringer slopes from 516.7 mASL to 516.5 mASL across 2m (Figure 22). This may be part of the same series of phenomena that characterise the BRU-I deposits ca. 20m to the north, which have at least four stringers ranging between 515.2 and 515.7 mASL, and also sloping subtly to the north, towards the modern North Rukuru.

![BRU-II-East-Profile](image)

**Figure 22** Section drawing of the BRU-II east profile. Artefacts represent all plotted finds from the m<sup>2</sup> immediately to the west of the profile; hence “floating” artefacts were excavated from deposits that were higher or lower in the western part of the square.

The east profile at Area I shows a long sequence of diverse geologic units that likely correlate to Clark’s (Clark *et al*. 1970) “Chiwondo Beds” at the base of the Ch-1a
excavation. There is a clear concentration of artefacts at the surface of the deposit; these correspond to the large drape of surface artefacts present across the site (Thompson et al. 2013a). The series of pebble stringers in Units 6 – 9 have been subjected to preliminary pIR-IRSL feldspar analysis, which is a potential alternative to the application of OSL to dating quartz (Figure 23). These ages presented here include both EBS (Early Background Subtraction) and LBS (Late Background Subtraction) estimates. Although these ages should not be taken as final estimates, they do suggest that alluvial fan formation in the area began prior to ca. 100 ka, and possibly even ca. 200 ka. This is consistent with other observations from the types of artefacts found in the area.

**Figure 23** Section drawing of the BRU-I east profile. Artefacts represent all plotted finds from the m² immediately to the west of the profile; hence “floating” artefacts were excavated from deposits that were higher or lower in the western part of the square.
The heavy erosion in the area is apparent in the shapes of the section drawings, which show at least one eroded and/or slumped aspect. The Area III excavation was emplaced to avoid this problem, and provide a “top-down stratigraphy” that is representative of the site (Figure 24). However, excavation revealed major differences in site formation at BRU-III from the other excavation areas, including episodes of carbonate formation. Artefact concentrations are also not as informative here, instead suggesting a very recent winnowing effect at the surface followed by diffuse artefact deposition uniformly throughout the underlying units.

Figure 24 Section drawing of the BRU-I south profile. Artefacts represent all plotted finds from the m² immediately to the west of the profile; hence “floating” artefacts were excavated from deposits that were in the northern part of the square.
V. SITE-SCALE GEOARCHAEOLOGY

Introduction

Geoarchaeological observations at the site scale include descriptions of sediment profiles, mapping, sampling for geochronology and micromorphology, and overall interpretations of site formation processes. Macroscopic site-scale geoarchaeology is led by Dr David Wright, whilst the Tübingen geoarchaeology team applies micromorphology and other micro-analytical techniques to the study of archaeological sediments and soils. Both aspects of the work are designed to reconstruct site formation histories and past human environments. In 2013, Flora Schilt carried out field work in Karonga for about one month (July 8th to August 4th), and Christopher Miller arrived on the 24th of July together with Dr David Wright (Seoul National University) and Dr Jeong-Heon Choi (Korea Basic Science Institute). The entire team departed on August 4th. Most geoarchaeological field work, such as sample collection and describing profiles, was carried out during the last 1.5 weeks of field work, as close collaboration between the different specialists was necessary.

Descriptions of sediment profiles are given in Appendix 1. Miller and Schilt collected 30 micromorphological block samples with correlating loose samples, 2 ground water samples for stable oxygen and hydrogen isotopic analysis and 7 carbonate nodules for stable carbon and oxygen isotopic analyses and uranium-series dating (Table 3). In addition to describing and sampling the archaeological profiles, several exposed profiles in the North Rukuru drainage were also studied to provide regional context.

The goal of the site-scale work is to understand how cultural materials were deposited and then potentially reworked through post-depositional processes, to aid in reconstructions of the timing and processes active on the local landscapes in which artefacts are found, and to develop independent palaeoenvironmental proxies that can be compared with palaeoclimatological data obtained from sediment cores collected in Lake Malawi (Scholz et al. 2011). Micro-analytical techniques also provide important contextual information for the interpretation of luminescence dating methods.
Table 3 All sites sampled, number of samples collected, number of samples processed, and years in which samples were collected.

<table>
<thead>
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<th>Sites</th>
<th># of samples</th>
<th># of samples processed</th>
<th>Years collected</th>
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<td>2011, 2012</td>
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<tr>
<td>MGD II</td>
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<td>4</td>
<td>2011</td>
</tr>
<tr>
<td>MGD III</td>
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<td>6</td>
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<td>2012, 2013</td>
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</tr>
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</tr>
<tr>
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</tr>
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</tr>
<tr>
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<td>0</td>
<td>2013</td>
</tr>
<tr>
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<tr>
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<td>2010</td>
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<tr>
<td>NRK (North Rukuru River Terrace)</td>
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<td>2013</td>
</tr>
<tr>
<td>KCR (Karonga-Chitipa Road)</td>
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<td>2013</td>
</tr>
<tr>
<td>MAL (Malema Chiwondo)</td>
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<td>2013</td>
</tr>
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Methods

Field Methods

Geologic sediment profile descriptions were compiled and photographed from all exposed excavation profiles (Appendix 1). Block samples for micromorphology were collected from exposed profiles with the aid of a knife, chisels and a rock hammer, and were either carefully wrapped in toilet paper and fixed with packaging tape, or casted with plaster of Paris to secure integrity during and after sampling (Goldberg and Macphail 2003). Many of the micromorphological block samples were collected in conjunction with samples collected for luminescence dating, in order to facilitate integration of the micromorphological results with those from the dating analyses.

![Micromorphological samples CHA III-13-03 (MEM 7237) and CHA III-13-04 (MEM 7236). The samples run parallel to OSL samples LM13-02, LM13-03 (holes to the right) and LM13-04 (not on this photo). Geological units included are 3-5 and 5-7. Unit 4 and 6 are the pebble layers.](image)

Micromorphological samples were preferably collected at the contacts between stratigraphic units, because blocks collected at contacts contain two types of sediment instead of one and multiple types of sediment in one sample minimise the number of petrographic thin sections that need to be produced. More importantly, the morphology of the contact between two units can often be informative about mode and energy of deposition, and the stability of former surfaces. Loose samples were taken from each geological unit included in block samples.
At the Bruce Area III site, carbonate nodules were collected for uranium series and stable carbon and oxygen isotopic measurements. The orientations of the nodules were marked on top with red nail polish after which they were carefully wrapped in toilet paper and fixed with packaging tape.

**Micromorphology**

Micromorphology is the study of oriented blocks of intact sediment in thin section using a petrographic microscope. The thin sections are studied under plane polarised light (PPL), crossed polarised light (XPL), blue light fluorescence, and oblique incident light (OIL) (Courty et al. 1989). From the analyses of the composition and fabric (geometry of the components, both solids and voids) of sediments and soils, interpretations can be made about the processes responsible for their formation and post-depositional modification. Thin section analysis allows the sampling and study of sediments and soils of all types (geogenic, biogenic, and anthropogenic) using the same methods.

The micromorphological samples collected during field work in Karonga are being processed at the Institute for Archaeological Sciences (Institut für Naturwissenschaftliche Archäologie - INA) in Tübingen, Germany. Block samples are oven-dried at 60°C for several days and impregnated with polyester resin under vacuum. The resin is prepared with 7 volume units of polyester resin (Viscovoss N 55S), 3 volume units of styrene (styrene for synthesis) and 5-6 ml/l hardener (MEKP). After hardening, the samples are cut into slabs from which, depending on the size of the sample and sample objectives, up to three uncovered 60x90mm thin-sections of 30 micron thickness are produced. Micromorphological description and analysis are performed following the criteria outlined by Courty et al. (1989) and Stoops et al. (2003). Based on field observations and results from thin section analysis, other analyses such as particle size analysis and Fourier Transform Infrared Spectroscopy (FTIR) will be performed on the loose samples.

Methods that we plan to apply in the near future include stable isotopic measurements ($\delta^{18}O$, $\delta^{13}C$) and uranium-series ($^{234}U-^{230}Th$) dating of secondary carbonates. In 2012 and 2013, loose samples of secondary carbonates were collected from several
archaeological and geological trenches located in different areas of the Karonga palaeolandscape (Mwanganda’s Village I and III, Test Pits 2 and 11, Bruce III). Stable carbon and oxygen isotope analysis provides information about past climate and vegetation, while measurements of isotopes in the uranium decay series can provide absolute ages for the formation of the carbonates. Stable carbon and oxygen isotope measurements will be executed on some of the collected loose samples, as well as on samples of carbonates from micromorphological blocks using methods outlined in Mentzer and Quade (Mentzer and Quade 2013), to directly link isotopic ratios to the micromorphological observations of secondary carbonates. Measurements of stable carbon and oxygen isotopic ratios will be conducted by Dr. Heinrich Taubald in the Isotope Geochemistry laboratory at the University of Tübingen. Prior to conducting stable carbon and oxygen isotopic measurements or uranium-series dating, carbonate nodules will be examined in polished cross section using petrographic and cathodoluminescence microscopes to assess any potential recrystallization that may have taken place. Loose samples of secondary carbonates will be directly dated using the $^{234}$U-$^{230}$Th disequilibrium method. The samples will be prepared at the University of Tübingen, and analysed in the School of Earth Sciences at the University of Queensland, Australia by Prof. Jian-xin Zhao and Dr. Gilbert Price. Funds for this work have been requested in a grant to the German Research Foundation (DFG).

**Summary of Site Observations**

**Chaminade III**

It was suggested by Dr Wright that dm-scale redox features could be an indication for rodent activity, because the looser material in burrows, compared to the surrounding matrix, would have been more susceptible to redoximorphy. The occurrence of large gravel pockets is most likely also related to burrowing activities, however by a bigger animal such as ground pangolin (*Manis temminckii*) or aardvark (*Orycteropus afer*). From field observations it therefore follows that the sediments in Chaminade Area III have been strongly disturbed by burrowing animals, which may be a factor in the laminar deposition of the artefacts noted in Section IV. After the profile was studied, discussed and described, five micromorphological samples were collected. The micromorphological block samples will be used to determine the depositional
formation of the units. The formation of the units containing larger amounts of artefacts is of the most interest, for example the gravelly units in which microliths could be easily recognised in the profile. Also, analyses will focus on the post-depositional alterations of the sediments, including bioturbation, in order to determine what processes may have influenced the archaeological record and to what extent. As in most other cases, micromorphological samples were collected parallel to, or at least from the same units as, OSL samples to provide information for the interpretation of the dating results. The extension of CHA III (Squares D98 to D94) was also excavated during the 2013 field season. It was sampled for OSL at the end of the field season but not for micromorphology.

**Chaminde IV**

Chaminde IV (CHA-IV) is located on the steep western slope of a ridge associated with alluvial fan deposits (Figure 26d). The area excavated had not (recently) been worked by farmers and was protected by trees. However, the area is surrounded by agricultural fields. The excavation yielded abundant stone artefacts, but the sediments of the upper ca. meter were strongly bioturbated by termite activity and large roots. The excavated sediments consisted of slope colluvium and it is expected that undisturbed deposits lie deeper and have not yet been reached. In the profile, immediately below the topsoil, an alternation of greyish sediments and more reddish reworked lateritic sediments of similar texture could be observed. These two distinct facies probably formed by burning of nearby fields by farmers as a preparation before planting (Figure 26a). When followed by rain, the burnt sediment from the barren fields would have washed down and become deposited on the slope side as colluvium. A micromorphological sample was collected from the alternating beds to test our interpretation based on macroscopic field observations. A second sample was collected from the sediments higher up in the profile as a reference sample for modern ant activity (Figure 26a, b).
Bruce

Test Pits 20 and 21 were excavated in August 2012 and re-exposed in 2013 for profile description and sample collection. Test Pit 20 is located next to a house on an alluvial ridge and consists predominantly of sandy deposits. One micromorphological sample was collected nearby in 2012 from one of the trenches that were dug for the septic tank system of the house. In 2013, we collected four micromorphological samples from Test Pit 20 that comprise the geological units 1-6 (Figure 27). These samples provide data on the deposition of MSA artefact-bearing deposits upslope of the main Bruce site. Abundant sharp-edged artefacts were discovered at >2m depth in 2012, mainly concentrated within ca. vertical 20cm of one another. Hundreds of artefacts had also been exhumed by the person digging the latrine pits in 2012, and these were scattered across the surface. However, the continued presence of artefacts at this depth in TP20 bodes well for the preservation of additional buried and intact deposit here.

Figure 26 Chaminade IV a) collection of a sample from dm-scale alternating beds of burned (grey) sediments and unburned reworked lateritic sediment. b) collection of a sample with known current ant activity in surficial sediments for reference. c) overview photo from CHA IV towards the west. d) overview of the hill before excavations at CHA IV were initiated. View to the north-northeast.
Test Pit 21 is located downslope and to the north-west of TP 20. It contained lagoonal, clay-rich deposits with a 5 cm thick layer of fine gravel near the base (Figure 28). The vertical surface of the profile had termite channels running over it, and was strongly reddened since exposure and covered with salts (Figure 28). This showed us not only how quickly termites build their channels over a freshly exposed profile-surface but also how over the course of only a couple of weeks the fresh surface of a profile can become weathered and oxidised, changing its colour from greyish to red shades. After scraping clean a column, the profile was described. Three micromorphological samples were collected. They include the units 1, 2, 3, 5 and 6.

Bruce Area I (BRU I) is located immediately east of a series of exposed channel bed sequences. In 2012, four OSL samples were collected from this eroded exposure before the area was further excavated (Figure 29).
In the second lowermost unit of the excavation (10-45 cm from the bottom), clayey intraclasts were observed (Figure 29b). These intraclasts could be the result of rodent burrowing. While bedding features in this unit and the sequence of gravelly bedding structures just above it indicates that no major post-depositional mixing has taken place, the intraclasts suggest that at least some bioturbation occurred in this lower part of the profile. However, only a few plotted finds were found in this excavation area, especially below the gravel beddings, and these are yet to be confirmed as artefacts. An assessment of the extent and nature of post-depositional disturbances at Bruce Area I is therefore not only necessary to reconstruct the natural and anthropogenic influences on the distribution of artefacts, but more importantly for the interpretation of results from OSL dating.

In thin section more information will be gathered about the formation of features such as the macroscopically observed intraclasts and how they may have impacted the archaeological record. In the lower and especially the middle part of the profile the intact channel bed sequences indicate that overall bioturbation was minimal. The units above the gravelly channel beds, however, appear considerably impacted by bioturbation. We collected three micromorphological samples from the bedded units and one from the transition of unit 8 to the more bioturbated uppermost unit 9. These samples will allow us to compare post-depositional mixing in the different units and
their possible implications for OSL dating and the archaeological record. The 2013 micromorphological samples correlate to OSL samples collected in 2012 and 2013.

Bruce Area II is located down-slope on a small elevation, probably kept intact by a tree while the surrounding area eroded away quite recently (Figure 30). Two thin pebble-rich lenses (stringers) were observed in the profile in which artefacts were abundantly present (Figure 31a, b). The upper part of the profile (Unit 5) showed insect disturbances, especially in the form of nests with fungus gardens, probably of leaf-cutter ants (Figure 31b, c). Two micromorphological samples were collected in order to span both pebble stringers.

Bruce Area III consists of coarse sandy and gravelly deposits (Figure 32). A calcic (Bk) horizon had formed in the lower units and is expressed by abundant carbonate nodules (Figure 32). This horizon is better preserved in the western part of the excavation than in the eastern part which may be the result

Figure 30 Bruce Area II, view to the southeast.

Figure 31 a) BRU II, E-profile showing the deeper units with artefacts clearly visible in the profile. b) Insect (termite) nests in upper units on step (W-profile). c) close up of a fungus garden. d) micromorphological sample of unit 4, including the upper pebble stringer and artefacts.
of differential decalcification throughout the solum. This can be determined with micromorphology, because decalcification features are easily recognised in thin section. We collected three micromorphological samples in Bruce Area III that will help us to reconstruct the site formation processes and differences in soil formation.

![Image of Bruce Area III](image)

**Figure 32** South-west corner of Bruce Area III. Collection of micromorphological samples and carbonate nodules for U-series dating and stable isotope analysis.

It is expected that the calcic horizon formed in place as a result of weathering. In that case the horizon is an indication for a former stable landscape when the climate was more arid than today. Artefacts deposited inside and on top of this calcic horizon could be linked to this ancient land surface. Isotopic analyses and uranium series dating performed on the sampled carbonate nodules will provide information about their age and the environment during their formation. Outcrops of similar secondary carbonates can be observed in Mwanganda’s Village as well as near the Bruce excavations (Figure 33). It is possible that the carbonates in both areas formed during the same period, but this relationship cannot be confirmed until the exact nature of the nodules in both areas
has been studied. It is possible that not all of the secondary carbonates are strictly pedogenic in origin. Fluctuations in groundwater level occur in the study area and can lead to similar carbonate formations.

**Figure 33** Secondary carbonates (brackets) crop out in the area of the Bruce excavations and near the excavations in Mwanganda’s Village. At Mwanganda’s Village, carbonate as well as water samples were collected in 2012 for reference when performing isotopic analysis. Elevations were measured at localities where carbonates outcropped.

**North Rukuru (Terrace 1)**

One of the goals of the broader geoarchaeological study is to reconstruct and date different stages of landscape development in the Karonga area. An important step in achieving this goal is understanding the drainage system. At the North Rukuru River, the southern fluvial cut bank (Terrace 1) was described and sampled (Figure 34).

**Figure 34** North Rukuru river (left) and cut bank (right).
Karonga-Chitipa Road (Terrace 2)

At a crossing between a minor dirt road and the main Karonga-Chitipa road, a man was digging a new latrine in front of his house, located on the second terrace of the North Rukuru River. He allowed us to describe the profile in the latrine pit and collect samples for OSL and micromorphology. We collected two small samples for micromorphology: one in the upper part of a B-horizon and one in the C-horizon of a soil formed in a profile consisting of sandy clay loam (Figure 35).

Malema

Malema camp is located ca. 10 km south of Karonga, where Chiwondo Beds outcrop over a large area. The camp was initially built to accommodate researchers and excavators involved in palaeontological research. The team visited the area to observe and document the Chiwondo Beds and compare them with Chiwondo deposits exposed in the MEMSAP excavations. No samples were taken.

Chaminade I

Miller and Schilt revisited Chaminade I to collect a small micromorphological sample of a unit containing abundant Fe/Mn nodules, as well as a large loose sample from the same unit (Unit 5). The objective in collecting these samples is to compare the nodules in thin section with nodules from other sites (CHA-II, APS and TP9) and to determine whether they formed in situ (orthic nodules) or derive from elsewhere (disorthic). It is possible that these nodules originally formed higher up in the profile and were moved downwards by insect activity (Crossley 1986). We can determine this by conducting
particle size analysis on both the sand grains present within the nodules after Fe/Mn extraction, and on the surrounding matrix sediments. Comparison of the textures will help us understand the relationship between the nodules and their present matrix. Iron and manganese can be removed with sodium dithionite, sodium citrate or comparable reducing agents. Sequestering agents, such as oxalic acid or citric acid, can also be used for this. Differentiating these processes is important because the artefact assemblage from CHA-I has now been analysed and refitted, and OSL ages have been finalised that are currently being prepared for publication (Figure 36).

Figure 36 Profile of the CHA-I site with OSL ages indicated

**Preliminary Micromorphology Results**

Preliminary thin section analyses have focused on samples collected from three excavations at the site of Mwanganda’s Village: Area I, a 2010 test pit near Area I and Area III. The results of these preliminary analyses suggest that depositional and post-depositional processes in the Chitimwe beds are complex and best addressed through micromorphology. For example, we have identified vertical and horizontal variation in pedogenic and groundwater-related processes, including gleying and other redox processes, bioturbation caused by termites, authigenic carbonate formation, clay
translocation, and secondary silicate formation. Importantly, micromorphological analyses show that many of the microscopic features associated with different pedological processes overlap one another (Figure 37). For example, the superposition of secondary carbonates over redoximorphic features and silica coatings on carbonate nodules provide direct evidence for diachronic variation in soil forming processes.

**Figure 37** Photomicrographs of soil thin sections from Mwanga’s Village Area I. The features observed in these thin sections show clear evidence for changing soil processes which are likely related to changing environmental conditions. A) q—quartz grain, cc—secondary carbonate nodule, ss—secondary silicates that overprints the secondary carbonate. PPL. B) I—iron staining (other abbreviations same as is A). Here, secondary silica overprints secondary iron staining. PPL. C) c—clay coatings; same abbreviations as before. The iron staining overprints clay coatings. PPL.
VI. OCHRE ANALYSIS

Overview

One of the ongoing research projects subsumed within MEMSAP is the investigation of ochre pigments present in MSA archaeological sites in the Karonga area. Such pigments have been linked by many authors to the origins of symbolism in the human lineage, especially material symbolism associated with the suite of activities which constitute recognisably modern behavior (Watts 2010, Henshilwood et al. 2009, McDougall et al. 2005, Barham 2002, McBrearty and Brooks 2000). Previous studies of ochre pigment have largely emphasized South African MSA sites such as Pinnacle Point 13B (Watts 2010, Marean et al. 2007) and Blombos Cave (Henshilwood et al. 2011, Henshilwood et al. 2009, Henshilwood et al. 2002). Examples of MSA ochre from elsewhere in Africa, such as that found in the Kapthurin Formation at Baringo, Kenya (Deino and McBrearty 2002) are incompletely published or occur as residues on lithic tools which are not suitable for provenance studies using current technology (Mercader et al. 2009). The only site in Central Africa at which ochre pigment has been excavated and studied using modern methods is Twin Rivers, Zambia (Barham 2000, Barham 2002, Barham 1998). MEMSAP research in northern Malawi provides an opportunity to fill an important geographic gap in our understanding of how the MSA varies across sub-Saharan Africa. This avenue of investigation has been pursued since 2011 and focuses on the formation mechanisms, distribution on the landscape, collection criteria used by MSA humans, transport distances, and modification strategies relevant to ochre pigments.

Methods

In 2011 ochre source identification and sampling fieldwork was undertaken by Andrew Zipkin during the MEMSAP field season from July through August. The range of geological processes associated with the term ochre is considerable; mostly due to the range of materials that fall under that umbrella label. Ochres are generally alteration or weathering products of iron ores, sulphide minerals, or other iron-rich rocks (Harben and Kužvart 1996). Common accessory minerals in ochre include quartz and other silicate minerals, hydrous aluminum phyllosilicates (clays), micas, carbonates,
evaporites, and organic matter (Green and Watling 2007, Watts 2002). As a consequence of this diversity, identifying which rocks and minerals to treat as ochre was a considerable challenge. For the purposes of this project, red and orange colored lateritic soils were not treated as a viable source of ochre pigment unless such material was found as a lens or bed within a sedimentary formation as opposed to exposed on the modern land surface. Emphasis was placed on sampling sources of ochreous rocks and minerals that occur as discrete point sources (lenses of ochreous clay accessible at an exposure) or as discrete objects (ochreous mudstone cobbles available in river beds). Ochre sources in northern Malawi generally exhibit complex mineralogy due to their sedimentary nature. Unlike ochres found in association with vein quartz and predominantly composed of hematite, such as those found near Twin Rivers, Zambia, much of the ochre in Malawi is a mixture of weathering products that have been eroded, transported, and deposited. Such ochres present a challenge for provenance studies because they represent the blending of the geochemical fingerprints of multiple rock formations.

Figure 38 Locations of ochre sources used in geochemical analysis.
Several sources were identified during the 2011 season but the three most thoroughly sampled were chosen for geochemical analysis (Figure 38). Multiple samples were collected from each source in order to determine the maximum amount of intra-source variability, with particular attention paid to acquiring ochre from different depths within a deposit and representing different colors of ochre when applicable. The Malema Camp source is a band of poorly lithified yellow-orange sandy silt within the Chiwondo Beds accessible at a stream-cut exposure. The Mulowe River near Mutowa Village source is a lithic polymict orthoconglomerate containing siltstone, claystone, mudstone, and quartz framework clasts. Lastly, the Kayelekera Village source consists of a shallow pit dug by local residents into the Karoo sandstone formation underlying the soil. Between 50 and 70 cm depth, the pit consists of quartz-poor, poorly lithified, clay and sand with mottled red, orange, yellow, and white colouration. Details regarding these three sources may be found in Zipkin et al. (2014, in press), Table 1.

Results

Trace element composition of the ochre samples from these three sources was determined using Instrumental Neutron Activation Analysis (INAA) performed at the University of Missouri Research (MURR) Reactor and using Homogenized Ochre Chip Laser Ablation Inductively Couple Plasma Mass Spectrometry (HOC LA-ICPMS). Both methods were used in order to determine whether or not HOC LA-ICPMS is capable of producing comparable results to a mature technique like INAA which has been used for decades in archaeometric research. The HOC sample preparation method was first developed by Green and Watling (2007) and has been further refined by Andrew Zipkin and John M. Hanchar (Memorial University of Newfoundland, MUN) for the purpose of allowing the analysis of ochre artefacts that are too large to fit into an ablation chamber for direct analysis but also require minimally invasive techniques that limit damage. The HOC technique entails extracting a small amount, potentially as little as 10 mg, of ochre from an artefact by drilling and then diffusing the resulting powder into neutral pH white glue. The resulting mixture is then dried into a solid film or chip and mounted for ablation on an epoxy disk. When geological source samples are analysed, the ochre is dehydrated in an oven and then homogenized using a mortar and pestle before mixing with the glue. Due to the addition of the glue binder, the results of LA-ICPMS done on
HOCs cannot be considered absolute values for the composition of an ochre sample. Rather, this technique is intended specifically for provenance studies where all samples are analysed using the same method and relative compositional differences between sources are sufficient for assigning artefacts to their deposit of origin. Zipkin et al. 2014 found that the trace element fingerprints obtained were robust enough that multivariate statistical analysis was able to distinguish among sources and uphold the Provenance Postulate for the three ochre sources considered. The ability to distinguish among these sources was verified by the INAA results.

Since demonstrating that it is possible to distinguish among at least some of the sedimentary pigment sources of northern Malawi, the ochre research turned its attention to archaeological ochre artefacts. The artefacts excavated from the Chaminade 1A (Ch-1a) MSA site by J. Desmond Clark and Van Eggers in 1965 and 1966 are curated at the Stone Age Institute (SAI) in Bloomington, Indiana, USA. The ochre from this excavation was never completely published, but is potentially significant because of the implications that material symbolism may have for the evolution of modern behaviour.

The Bruce site, which has been provisionally equated with the Ch-1a site (see Section IV), yielded 18 pieces of red ochre on the surface, weighing a total of 134.1 g. Among the eighteen pieces of surface ochre collected, eight pieces exhibit unambiguous evidence of modification including convergent facets, flat ground surfaces, knapped flakes, and incisions (Figure 39). The initial goals for the site included conducting new excavations to determine if any undisturbed sediments remained, determining chronometric ages for the site, and doing trace element composition analyses of any ochre artefacts found on the surface, in the new excavations, and from the original Clark Ch-1a ochre.

![Figure 39](image-url) Ground ochre plaque from Ch-1a (left) and two ground or incised ochre fragments from the surface of Bruce (right).
The ochre-specific research questions included the following:

**Research Question 1:** What is the elemental composition of the ochre artefacts from CH-1A and Bruce and how variable is each assemblage?

**Research Question 2:** Is the collection of ochre artefacts excavated by J.D. Clark and colleagues at Ch-1a of comparable trace element composition to the ochre collected on the surface of the “Bruce” site by MEMSAP?

**Research Question 3:** Do the ochre artefacts from either assemblage show affinities to present day ochre sources in northern Malawi?

In order to address these questions, during the 2012 field season the previously mentioned ochre artefacts from the surface of the Bruce site were collected. Additional ochre sources were sampled, with an emphasis on ochreous boulders and cobbles in riverbeds throughout northern Malawi. Walking surveys of the Mkungwe tributary of the North Rukuru, and of the Lufira, Ruasho, Wayi, and Remero Rivers were undertaken by Andrew Zipkin. All rivers except the Remero yielded at least sporadic ochreous cobbles and boulders, and more rarely, examples of bedrock exposures on the banks weathering in situ into ochre. All source samples and the surface artefacts from Bruce were exported to the United States for geochemical analysis; the surface artefacts will be returned to Malawi in July 2014.

Since MEMSAP interest in archaeological ochre in the Karonga area was initiated by the report of pigments at Ch-1a in Clark et al. (1970), the next logical step was to incorporate this assemblage into the broader MEMSAP pigment sourcing project. Andrew Zipkin traveled to SAI during late 2012 to describe and photograph the ochre artefacts excavated from CH-1A in 1965 and 1966. Just over 2 kg of ochre artefacts were identified in the SAI collection of which about 130 g were too fragile to sample. Ultimately 14 artefacts were drilled to extract ochre powder for trace element analysis. These samples, the Bruce surface artefacts, and the Malawi ochre sources samples from the 2012 field season were prepared for LA-ICPMS using the HOC technique. Analyses were carried out at MUN by Andrew Zipkin and John Hanchar during February 2013. In addition to LA-ICPMS, each HOC was also analysed using Electron Microprobe Analysis.
(EMPA) in order to measure iron content and use this element as an internal standard for the purpose of transforming counts per second into ppm concentrations for trace elements. EMPA was done at the University of Maryland by Dr. Phillip Piccoli in collaboration with Andrew Zipkin.

The results of the LA-ICPMS and EMPA analyses of the ochre source and artefact samples were presented by Andrew Zipkin at the bi-annual meeting of the East African Association for Paleoanthrology and Paleontology in Mombasa, Kenya on July 31st, 2013. The EMPA measures of iron found that the all ochre artefact samples were relatively low in Fe content, with none exceeding 30% (Figure 40). In addition, it was found that the Clark Chaminade 1a ochre artefacts exhibited significantly (ANOVA: Bruce Surface ≠ Ch-1a (α = 0.05 p = 0.001) lower iron content than the Bruce surface collected artefacts. This does not preclude the ochre artefacts from each assemblage being derived from the same source since iron content can vary radically within a single ochre source.

Research question #1 was addressed using Upper Crust Normalized Spider Plots and Chondrite Normalized Spider Plots to compare the artefacts in each assemblage (Figure 41). The two assemblages showed generally similar patterns of trace element composition in the Upper Crust Normalized plots in which all elements measured by LA-ICPMS were considered. All elements were depleted relative to the upper crust of the earth with the exception of a few artefacts from CH-1A that were enriched in Nickel. Both assemblages displayed a marked depletion of Strontium and a notably minor depletion in Lead. In the Chondrite Normalized plots, only Rare Earth Elements (REEs)
were plotted. All samples showed a progressive depletion of rare earth elements from heavy to light elements, the only exception to the gradual decrease being marked Cerium anomalies, both positive and negative, relative to the elements Lanthanum and Praseodymium. Normally Cerium should behave similarly to these two elements and its behaviour here, particularly in those specimens where Cerium content is depleted relative La and Pr, suggests that Cerium may be 4+ rather than trivalent due to oxidising conditions. Interestingly, Tim Young reported similar, variable Cerium anomalies in his ICPMS analysis of ochre from Twin Rivers, Zambia and the significance of this pattern, if any, will require further investigation to elucidate (Young 1999).

**Figure 41** Upper Crust Normalized plot of element concentrations in the Cha-1a (red) and Bruce (yellow) artefacts.

More advanced analyses of the trace element composition relied upon multivariate statistical methods which are described in detail in Zipkin *et al.* (in press, 2014). A bivariate plot was generated using the mean compositions from 5 LA-ICPMS analyses of each artefact, with 34 measured elements normalized to iron content, log\(_{10}\) transformed, and plotted with a Principal Component Analysis. On a qualitative level, the Bruce surface ochre assemblage and the Ch-1a assemblage excavated by JD Clark were indistinguishable. The confidence ellipses for the two assemblages substantially overlapped. The only truly notable trend was that the Bruce surface assemblage is less internally variable than the excavated Ch-1a assemblage and generally clusters within its 90% confidence ellipse. The results of these analyses do not conclusively confirm that the Ch-1a ochre assemblage is identical in composition to the Bruce surface
assemblage, but more importantly they do not preclude the two assemblages in fact being one and the same (Figure 42). If the Bruce surface assemblage and the Ch-1a assemblage were found to be unambiguously chemically different this would complicate the present interpretation that Bruce is the same site as Ch-1a. For the time being, research question #2 remains open but presently available data suggest that the Bruce and Chaminade ochre derive from the same source or sources.

![Figure 42](image.jpg)

**Figure 42** PCA using 34 elemental variables: Each point represents the mean composition of an artefact, averaged from 5 analyses and standardised to the Fe content of each artefact, log_{10} transformed. Red is Ch-1a artefacts and yellow are from Bruce.

Finally, with regard to research question #3, the trace element fingerprint of the ochre artefacts were compared to the fingerprints of all analysed northern Malawi ochre sources, including the three sources identified in 2011 and the four river sources sampled in 2012. Canonical Discriminant Analyses were used in an attempt to assign ochre artefacts to these sources. The sources were largely distinguishable from one another but neither artefact assemblage as a whole, nor any sub-group within either assemblage, clearly matched a source (Figure 43). Considering how erosive the landscape of northern Malawi is, there is a distinct possibility that the ochre sources available during the MSA are simply no longer present.
Figure 43 Canonical Discriminant Analysis: Discriminant function built using 34 elements and mean values for all ochre source samples collected. Artefact means treated as unknown origin and plotted. Red triangles are Ch-1a artefacts and yellow are from Bruce.

However, source sampling thus far has relied on a combination of knowledge from local informants and walking surveys of river beds. A more comprehensive ochre source identification program in the future might begin by investigating bedrock exposures in the highlands in north western Malawi, from which the ochre found in rivers beds might ultimately derive. In addition, extreme northern Malawi along the Tanzanian border has been entirely unaddressed with regard to pigment sources. Jackson Njau (Indiana University) has suggested that the ochre artefacts from Ch-1a bear a resemblance to pigment sources in southern Tanzania. Lastly, the Chinese mining firm Hainan International Resources has just begun mining limonite, a rock used as yellow ochre pigment, at Nyungwe in Karonga District. This deposit has not as of yet been sampled and raises the possibility that major ochre sources relatively close to Karonga have been overlooked thus far. With sufficient training in the identification of ferruginous pigments and how to sample a source effectively, it may be possible to carry on ochre exploration during an “off-season” using only Malawian personnel and more effectively canvas areas of operations for sources.
VII. STONE ARTEFACT ANALYSIS

Overview

Analysis of the stone artefacts recovered by MEMSAP is being led by Dr Alex Mackay and Ms Sheila Nightingale. Although they work closely together to ensure comparable results, each undertakes analysis of assemblages from different sites, and both have contributed to this section of the report. Major activities in 2013 included: 1) completion of refitting analysis and recording of the MGD-I artefact assemblage; 2) completion of analysis of artefacts from MGD-III; 3) completion of analysis of artefacts from CHA-I and CHA-II; 4) preliminary artefact analysis from a column sample of plotted finds from CHA-III; and 5) analysis during the 2013 field season of artefacts recovered in 2012 from test pits, excavated sites, and a geological trench.

Analysis of artefacts from MGD-I, CHA-I, and CHA-II has been conducted in Karonga during prior field seasons, and in order to complete analysis in a timely manner, additional work was carried out in 2013 on artefacts temporarily exported to the lithic analysis laboratory at The University of Queensland (UQ) and at the City University of New York (CUNY). All artefacts from CHA-I and MGD-I have now been returned to Malawi, and the remaining exported artefacts from CHA-II will be returned in July 2014.

Because some artefacts from CHA-I and CHA-II had not been shipped to New York following the 2012 field season, these were also analysed in Karonga in 2013. Refitting of artefacts from the black nodule layer at CHA-I was undertaken, and follow-up analysis was completed for this assemblage. In order to produce artefactual data to complement the OSL dating program at Bruce, the plotted artefacts from Area I were analysed (time unfortunately did not permit the analysis of the sieved fraction of the assemblage). Finally, the artefacts from the Sadala South geological trench were analysed. The analytic focus for Mackay in 2013 was completion of remaining artefacts from Mwanganda’s Village (MGD) excavations, and preliminary analysis of a sample from Chaminade III (CHA-III).

In total during the 2013 fieldwork, over 3900 stone artefacts were analysed by Nightingale according to quantitative and qualitative characteristics in a typo-
technological classification system described in Thompson et al. (Thompson et al. 2013a, Thompson et al. 2012a). Artefacts from Test Pits 8, 9, 10, 12, 13, 20, and 21 were all analysed in their entirety in 2013, and no artefacts had been recovered from Test Pit 11. Mackay analysed a total of 1976 new plotted and sieve-recovered finds, of which 1635 came from MGD and the remaining 341 from CHA-III.

**Rationale and Objectives**

Analysis of the rich stone tool assemblages of the Karonga region will provide a clearer and more complete picture of traditions of landscape and resource exploitation by Middle and Later Stone Age people. Even a cursory look at the artefactual record of the area shows an incredible diversity across both time and space, and the importance of this research cannot be overstated. Historical biases in the field of archaeology have resulted in a geographic disparity of exploration of the African continent; areas such as eastern and southern Africa have been the subjects of intense archaeological inquiry for many years, while other regions have received much less attention. Such is the case in northern Malawi. A major goal for the analysis of the stone artefacts from Karonga, therefore, is to meaningfully examine the trends and traditions of Middle Pleistocene populations, living around the time of the emergence of our own species. While patterns may emerge that link this area of southern central Africa to populations to the north or the south, it is equally likely that the MSA stone tools of Karonga will reveal local traditions that have developed *in situ*. This will add to our increasing knowledge of MSA people as varied, adaptable populations with unique ways of living, both suited and responsive to the immediate environment and cultural traditions. The analysis of the Karonga lithic assemblages is therefore aimed at uncovering quantitative patterns of resource exploitation and technological systems, and placing these in a temporal and geographic framework at the local and continental scales.

**Methods**

All stone artefacts from excavated contexts were examined on a number of qualitative and quantitative variables that are comparable to methods used by lithic analysts working elsewhere in Africa (Tostevin 2011, Tryon and Potts 2011). Raw material was classed according to type, grain size, and matrix homogeneity, variables demonstrated
to affect characteristics of flaking quality (Braun et al. 2009). Weathering was classed on a scale of 0 to 3 after Thompson et al. (Thompson et al. 2012a). These data were collected to assist site formation interpretations, as assemblages that are in a primary depositional context will have much less edge damage than transported assemblages. As a corollary of weathering measures, recent edge damage is was also recorded. Weight and maximum dimension was recorded for all recovered artefacts, providing a minimal data set for those objects that could not be ascribed to a technological class more specific than “angular shatter.”

All artefacts were classed according to technological component—flake, core, angular shatter (incidental breakage resulting from knapping, or broken components that cannot be confidently identified), hammerstone, manuport, other—and according to completeness, including preserved portions: proximal, mesial, distal, etc., following Inizan (1999). Metric attributes of flakes and cores (length, width, thickness) recorded variation in their shape. Exterior and interior platform angles, platform width, and thickness were also recorded for complete flakes and those proximal flake fragments significantly long enough to preserve such dimensions, as these have been shown to influence flake morphology in experimental programs (Dibble and Rezek 2009, Lin et al. 2013, Rezek et al. 2011), and may serve as proxies for knapping control. On both flakes and cores, preserved cortex was estimated to 5% of exterior/dorsal surface coverage; cortex coverage is not only indicative of a flake’s relative position in a reduction sequence, but when assemblage-wide trends are considered, can demonstrate the degree to which toolstone was reduced as a matter of practice, which itself has been demonstrated as a proxy for raw material availability (Kuhn 1991, Andrefsky 2005, Braun et al. 2008, Dibble et al. 2005). Dorsal scar patterns were recorded for sufficiently complete flakes, while acknowledging that a given flake morphology is not exclusive to a particular reduction method (Boëda 1995). Reduction strategies are more easily discerned on cores than flakes, and the cores of the Karonga assemblages can generally be classed as platform, centripetal, or ‘casual’ (≤5 removals) cores. These main core types can be further subdivided (i.e., single platform, multiple platform, discoidal, Levallois, etc.) to produce a more detailed understanding of reduction trends. Both discoidal and Levallois cores are hemispherically organised, with opposed upper and
lower surfaces. The volumes of these surfaces were measured to produce convexity ratios (after Thompson et al. 2012), which can be used to compare the technical rigidity of the various reduction strategies for the production of flakes.

**Results**

**Test Pit 8**

Test Pit 8 revealed a relatively deeply buried LSA assemblage. Based on its location, it is almost certainly the same locality as Clark’s site “Chaminade 3”, or Ch-3 (Figure 18), as briefly described in Clark et al. (1970). A single extremely weathered flake fragment was found at the surface of TP8, and was the only artefact recovered in the first metre of the pit. Between the depths of 100cm and 160cm (Contexts 6, 7, 8), 93 unweathered artefacts, predominantly on quartz, were recovered. The average size class of all artefacts in these contexts is 1.91, and no artefacts were over 30mm in maximum dimension.

Relatively little cortex remained on any of the artefacts. Contexts 9 and 10 (160-200mm depth) were considerably more productive, with 495 and 437 artefacts, respectively (Figure 44). As in the layers above, artefacts were predominantly on quartz (including a considerable amount of crystal quartz), showed very little evidence for weathering, had an average size class of 2, and had very few cortical elements. Context 10 also produced a backed microlith. In all contexts, artefacts were mostly whole or fragmentary flakes and angular shatter (flake pieces); two complete quartz radial cores (both SC 3) and one broken quartzite platform(?) core (preserved SC 6) came from Context 9, and two quartz radial cores (SC 3 and 4) came from Context 10. Three small chert(?) flake pieces
were also found these lower contexts. The small size of all recovered artefacts, the predominance of quartz, and the lack of strongly diagnostic MSA elements all suggest an LSA attribution, despite the fact that easily recognizable microlithic cores or retouched pieces were not common.

**Test Pit 9**

Test Pit 9 produced only 58 artefacts. The majority of these were found between 60 and 120cm below the surface. Two relatively large flake fragments from Context 1 could have resulted from Levallois reduction, though they may also simply have been radially flaked. Context 4 was slightly more interesting, with singular possible occurrences of quartzite Levallois and laminar flakes fragments, one retouched complete flake, three flake fragments/flake pieces on an unidentified material (perhaps sandstone or silcrete), and one distinctly laminar flake fragment on fossil wood; all artefacts from Context 4 are in fresh condition. Context 5 also produced two fresh, non-refitting flaked pieces (core fragments) of fossil wood. Interestingly, a fragment of ceramic or brick was also found in Context 5, suggesting that the assemblage has been subject to post-depositional processes. One large (SC 7) quartzite flake fragment was found in Context 8, and nothing below. The lack of weathering or abrasion on most of the artefacts does not support the hypotheses that these artefacts were considerably moved from their original depositional setting, but the presence of the brick/ceramic fragment is somewhat confounding. Typologically, Test Pit 9 produced artefacts that may well date to the MSA, but the small sample size prevents much further confirmation.

**Test Pit 10**

A total of 166 artefacts were recovered from Test Pit 10. Although this is a very modest amount, the artefacts from this test pit show a pattern previously unseen in the Karonga assemblages. The upper contexts contain very little artefactual material. In Context 1, a single (modern?) bone fragment was found, as well as 3 quartz and 5 quartzite flake fragments or flake pieces, all in unweathered condition, all less than 50mm in maximum dimension. A burned and broken quartzite cobble was also recovered from Context 1. Context 4 (60-80cm) produced a single burned quartzite cobble. The main concentration of artefacts occurs in Context 8 (140-160cm below the surface), where a
total of 145 lithic objects were found. Fifty-three quartz artefacts were recovered, mostly flakes, flake fragments, and flake pieces, with minor weathering and an average size class of 3.93; cortex is variably present on the artefacts, but regularly occurs across ~50% of preserved surfaces. Two quartz cores were also found: one complete casual core and one fragmentary radial core. Seventy-nine quartzite flakes, flake fragments, and flake pieces came from Context 8, as well as 2 burned radial cores and one centripetal Levallois core. Additionally, six burned quartz cobbles and five burned quartzite cobbles were recovered. In total, 48 lithic objects (including the cobbles, cores, and flakes and flake pieces) from Context 8 show evidence for burning—blackened or otherwise colour-affected surfaces, and increased friability of the stone matrix. Furthermore, it is fairly clear that these stones were burned before flaking, as the blackened surfaces are restricted to the cortical areas of the stones, and where heat has caused a change in the color of the rock—penetrating the exterior surface—the flake margins cut across these color changes. Context 9 only produced five artefacts: four fragmentary flakes and flake pieces (two each on quartz and quartzite) and a complete quartzite hammerstone with diagnostic pecking at each end—one more so than the other. While the artefacts from Test Pit 10 are not entirely diagnostic, the general centripetal pattern of reduction, their size, and the relative frequency of cortical pieces is reminiscent of objects from CHA-II, and it is likely that the main artefact concentration dates to the MSA. The frequency of objects that evidence burning prior to flaking—including a number of complete and broken but unflaked cobbles—is unique in the Karonga assemblages. A casual test in which quartz and quartzite cobbles were placed directly in or adjacent to a fire for several hours shows similar types of modification to the cortex and immediately underlying stone matrix, and it seems unlikely that the human use of the burned stones found in Test Pit 10 would have been entirely unintentional.

Test Pit 12

Test Pit 12 produced only 66 artefacts, all of which come from the top metre of the unit. Context 1, with 16 artefacts, shows some characteristics that are typical of the MSA in Karonga, including a higher proportion of larger quartzite flakes and fragments (average SC 4.92), some of which may have been reduced via the Levallois method. Most
artefacts from this level are slightly weathered—including regular edge damage—which is unsurprising at the surface. Context 2 produced a large portion of broken rocks, but these do not appear to have been anthropogenically modified. With a total of 42 artefacts, Context 2 is the densest at Test Pit 12, and artefacts are slightly to consistently weathered, including three chert artefacts, one of which has developed a significant patina. The 15 quartz artefacts in Context 2 have an average size class of 3.09, while the 24 quartzite flake fragments and flake pieces are marginally larger with an average size class of 3.81; most artefacts on either material retain cortex. No artefacts were found in Context 3, and a single slightly weathered chert flake was recovered in Context 4. The only interesting finds from Test Pit 12 are three complete quartz primary flakes, all in fresh condition, that were found in Context 5 along with four other pieces of quartz flake fragments or flake pieces. None of the artefactual data from Test Pit 12 strongly suggests that this was an area of primary deposition, though the artefacts are typologically consistent with other MSA assemblages from Karonga. This site is within 100m of Clark et al.’s (1970) excavation at Ch-2.

Test Pit 13

This test pit produced over 1500 artefacts, approximately 75% from a concentration 40-80cm below the modern surface. Quartz slightly dominates the total assemblage (54.8%); quartzite is mostly fine-grained, but a coarse-grained, quartz-like variety is also present. The total assemblage shows a high frequency of edge damage though not edge rounding, suggesting secondary deposition and quick burial, rather than long-term entrainment in a fluvial system or exposure on land surface. Cores are typically ‘casual’ or discoidal, with some typological affinities to Sangoan-like “end-“ and “side-choppers” described by Clark (Clark et al. 1970). Two quartzite cores show with some, but not all, of the qualities required of Levallois reduction (per Boëda [1995]). Specifically, both cores have opposed, hierarchically related convex surfaces, and reduction was ostensibly aimed at the production of a preferential flake, but ‘preparation’ flakes of the lower surface are sometimes flaked parallel to the intersecting plane, or fail to produce correctly oriented striking platforms for preferential flake removal. Though numbers are small, this may represent some experimentation with approaches to reducing toolstone, and are not seen elsewhere in the Karonga assemblages. A group of cores-on-
flakes are remarkable as they represent the only such cores in the entirety of the MEMSAP assemblages from excavations or test pits, where river cobbles have otherwise dominated as core blanks. Based on the lack of true Levallois reduction from an otherwise artefact-rich assemblage and the typologically Sangoan-like artefacts, this assemblage is inferred to be older than either Chaminade I or Chaminade II.

Test Pit 20

Test Pit 20 was excavated to a depth of 3m, and the majority of the 410 artefacts recovered come from the lowest meter of the unit. Six relatively unweathered quartz and quartzite artefacts were found in Context 1, though these could have simply been surface finds. A single quartz flake was recovered from Context 3. Between 100 and 160cm below the surface, the 27 artefacts found are relatively small (average SC 1.28 – 2.75), minimally weathered, flake fragments and flake pieces on quartz and quartzite, with the exception of a broken radial quartzite core in Context 8. No finds were recovered in Contexts 9 and 10, and only six (a quartz flake fragment and flake fragments and flake pieces) from Context 11. Contexts 12-14 have the highest artefact densities in Test Pit 20, and the most interesting diagnostic pieces for identifying technological behaviors. Context 12 produced a total of 77 artefacts, predominantly on quartz. Forty-eight quartz flakes, flake fragments, and flake pieces had an average size class of 2.38, were overwhelmingly in fresh condition, and preserved minimal cortex. Two quartz cores were excavated from Test Pit 20—a casual core (≤5 removals) and a Levallois core-on-flake, a novel approach to core reduction in Karonga that has otherwise only been found in the Sadala South materials. Twenty-two quartzite flakes, flake fragments, and flake pieces were found, slightly larger than the quartz components (average size class 3.32), and with slightly more cortex preserved, but the same degree of freshness. One quartzite primary flake clearly came from a cobble that had been burned prior to reduction. Five additional flakes of an unidentified stone type were found—all as dark blue/black material, and it seems likely that these flakes came from the same core. Context 13 (140-160cm below the surface) produced the largest number of artefacts (n = 177): 73 quartz flakes, fragments, and flake pieces, with an average size class of 2.96, some cortex preserved, and almost no evidence for weathering. Ninety-five quartzite complete and fragmentary flakes and flake pieces came from Context 13, and
as in the context above, were slightly larger (average size class 3.39) with slightly more cortex, but minimal weathering. Quartzite flake fragments show a general trend of centripetal reduction. One chert and one silcrete(?) artefact were also recovered. Additionally, seven quartzite cores were found, including a centripetal Levallois core, discoid cores, platform/multiplatform cores, and a flake that had weathered considerably before being flaked again. Multiple refits of cores and flakes were found in this Context, which may suggest that post-depositional processes have not significantly reworked this material. Context 14 includes two cobbles that were possibly tested for quality by ancient knappers, and one of them appears to have been burned first. Four chert flake fragments and flake pieces were found, with variable degrees of weathering. Thirty-three quartz flake fragments and shatter and one complete radial core came from Context 14; all had minimal weathering and a sizeable amount of remaining cortex on exterior surfaces. Sixty-seven quartzite flake pieces and fragments were found; as in overlying contexts, quartzite pieces were slightly larger than quartz. One quartzite centripetal Levallois flake was recovered, in addition to two quartzite cores--one discoid/centripetal core and a likely Levallois core in the process of being rejuvenated—and a single core-chopper. The core-chopper has been classed as such because of the seemingly deliberate attention given to reduction of only one end of the cobble, where many removals were made in an apparent attempt to produce a relatively thin, long edge, whereas the other end of the cobble was left completely unreduced. Artefacts are less dense in Context 15, where only two quartz and eight quartzite flake fragments and shatter were found, with significantly higher degrees of weathering than in contexts above. Based on the minimal evidence for weathering in the main artefact concentration, and the typologically diagnostic elements (Levallois flakes and cores, the degree of reduction), it appears that the lower levels of Test Pit 20 are consistent with many characteristics of the MSA in Karonga, although the presence of somewhat novel forms (Levallois core-on-flake, core-chopper) is notable.

Test Pit 21

Although excavated to a depth of 2.8m, only 176 artefacts were found, predominantly from the lowest contexts. In the upper levels, Context 4 produced 14 quartz and quartzite flakes, flake fragments, and flake pieces, all relatively unweathered. An
unworked nodule, likely chert or quartzite, was also found. No artefacts were recovered from Contexts 5-11. Context 12 had just three artefacts, including a complete quartzite flake and two quartz flake pieces. Context 13, by contrast, had 131 finds: 61 quartz and 70 quartzite flakes, fragments, and flake pieces, with average size classes of 3.17 and 3.55, respectively, relatively little weathering and moderate cortex remaining. Several quartz primary flakes were found, and the artefacts in general show slightly more platform preparation and degrees of reduction. Context 14 produced 28 artefacts: one tested quartzite cobble, and a fairly equal representation of quartz and quartzite flake fragments and shatter, including a centripetally reduced Levallois quartzite flake.

**Chaminade I (CHA-I)**

One goal of the 2013 field season was to assess the CHA-I artefacts for refits. This was a time-consuming exercise, but 43 objects from the black nodule layer were refit into 12 groups. Because of time constraints, refitting was only possible to assess the finds from the main artefact concentration, but valuable data were collected nonetheless (Figure 45). Specifically, it is clear that refitting pieces come from discrete clusters and are not scattered all across the excavation area (Figure 46).
The plotted finds from Bruce Area I (BRU-I) were analysed toward the end of the 2013 field season in order to provide archaeological context for the preliminary pIR-IRSL results. Due to time limitations, it was not possible to analyse the sieved finds, so the data produced from this analysis are incomplete. Nevertheless, the artefactual data show that artefacts are concentrated in the top ten contexts; Contexts 11-19 only had 32 plotted artefacts. In Contexts 1-10, artefacts are predominantly complete and fragmentary flakes and flake pieces on quartz and quartzite, and are relatively small (average maximum dimensions are typically less than 20mm). Diagnostic elements are rather limited, though the artefacts are similar in type and technological affinity to MSA assemblages elsewhere in Karonga. Levallois elements are limited, but in Context 10, a Levallois core was found in the same level as a large core-chopper, similar in form to that found in Test Pit 20 and as surface finds in the Bruce area. This context is associated with the provisional pIR-IRSL age of ca. 112 ka, while the very small numbers of artefacts between Contexts 11-19 are associated with the preliminary age of ca. 148 ka.

**Bruce varia**

Although not systematically analysed, a number of interesting artefacts were discovered through excavation and on the surface in the Bruce area. Two large core-tools were found on the surface between Area 2 and Test Pit 21; grading between handaxes and...
chopper-cores, these large objects are similar to those described for the lower levels of Clark’s 1965 excavation at Chaminade 1A. It is a bit surprising that this type of artefact was not encountered during the systematic surface collection in 2012, but that collection took place further downslope and may relate to a different depositional sequence. The presence of these artefacts does reinforce the idea of an older component in the Chitimwe Beds, even if they are currently undated (Figure 47).

A piece of what appears to be flaked bone was found during excavation at Area II, from Context 17 in Square A1 (Lot 2149). While it is possible that this is a non-anthropogenic occurrence, the object has morphological characteristics that are identical to those seen on flaked stone, including a clear platform for percussion, a bulb of percussion, and a previous removal on what could be considered the dorsal surface. It would be highly unusual if this was confirmed as bone preserved in the lateritic sediments at Bruce, although the presence of soil carbonates in the area may have acted as a buffer against dissolution of artefacts manufactured on fossil bone. This phenomenon has also been found to occur at Mwanganda’s Village {Thompson, 2009 #5558}.

To make this find even more remarkable, an additional seven pieces of flaked(?) bone were recovered from Context 16, immediately above, through wet-sieving, and in excavation in Square A0, Context 22 (Figure 48). These pieces also show characteristics that would be expected of flaked stone, though none are unequivocally flaked. The margin of one piece is irregular, and looks a bit like a cranial suture, while a different piece seems to have on its dorsal surface

Figure 47 Surface finds from Bruce that suggest an older depositional sequence at the locality.
a bit of the exterior bone surface. In the same depositional layer, a series of very large, extremely fresh quartzite flakes were found; these pieces have not been shown to refit, but color and quality of the raw material suggest they likely come from the same core.

Sadala South

This 1x3m geological trench approximately 6km south of Karonga was not excavated archaeologically, but several artefacts unearthed during its emplacement in 2012 were collected so that their potential significance could be explored. This site shows the clearest evidence for an Acheulean occupation of the Karonga region. Of the 98 artefacts recovered (6 from the upper unit, 92 from the lower unit), the most compelling is an unweathered, finely worked chert handaxe. This was recovered at below 1.5m depth from the trench, from which OSL and Cosmogenic
nuclide dating is currently underway.
At 116mm in length, the Sadala South handaxe is the largest chert artefact recovered in any subsurface investigation of the Karonga region. Only 43 chert objects have been found among the 15,000+ artefacts analysed thus far from MEMSAP excavations; with the exception of four, are all 30mm or less in maximum dimension. A bifacial, centripetally flaked chert core (max. dimension = 45mm) was found in the same unit at Sadala South, and similar to the quartzite cores from Test Pit 13, it shows elements of technological organization consistent with Levallois reduction, while failing to maintain others. The presence of these two relatively large but extensively flaked chert artefacts is highly incongruous with the other Karonga assemblages, as well as the known locally available raw material.

Recent surface survey approximately 60km south of Karonga has revealed a slightly higher incidence of chert artefacts and a few unworked chert nodules; this increase in size and number of chert suggests a primary source to the south of Karonga. At Sadala South Quartz is slightly more common in the lower unit (57.1%), and the vein quartz-like quartzite found at Test Pit 13 represents 11.9% of the total quartzite at Sadala South. No Levallois artefacts were recovered from the lower unit, though one Levallois core on a flake was found in the upper sandy unit of the trench. This piece is strongly reminiscent of the cores-on-flakes noted at Test Pit 20, though this and the example from Bruce show a novel approach at Karonga to the production of a Levallois core. The flake’s ventral surface served as the upper ‘Levallois’ hemisphere, providing natural lateral and distal convexities without extensive ‘preparing flakes,’ while the flake's cortical dorsal surface provided the volume typically associated with lower hemispheres of Levallois cores (Boëda 1995). Artefacts show little evidence for post-depositional movement or weathering, and it is likely that Sadala South is a stratified, in situ occurrence of Acheulean and overlying MSA deposits. Expanded and controlled excavation at Sadala South will provide an essential data set for addressing the Acheulean in Central Africa by exploring the innovating behaviors of our species’ immediate forbearers.
MGD-I

The principal objective of excavation at this site was to understand the archaeological deposits that overlay those designated by Clark “elephant buthery site”. After discovery in 2011 of an intact series of deposits with refitting artefacts, a secondary objective became to recover and refit other artefacts from the area – with an aim toward understanding the distribution of activity areas and possibly identifying the site boundaries. This study shows a clear concentration in the centre of the excavation area (Figure 50). After refitting was completed, techno-typological analysis of the artefacts was also completed in 2013.
Figure 50 3D (a, b, c) and 2D plan view maps of the distribution of plotted finds (small black dots) relative to plotted finds that are part of a conjoining unit (coloured circles). The 3D view (southeast) allows visualisation of the sedimentary units as volumes.

A total of 3332 stone finds were recovered from excavations at MGD-I, of which were 3034 were identified as flaked or battered stone artefacts. The vast majority of these are flakes (n=2196), followed by angular fragments (n=655), cores (n=124) and retouched flakes (n=53). The assemblage includes a minimum of 62 identified conjoin sets and 38 raw material units, attesting to exploitation of gravels available locally to the site. While conjoin sets occur in all layers, they tend to be concentrated in the middle stratigraphic
layers of the deposit (Figure 50), most notably in the brown clayey sands (BCS). Artefacts from MGD-I also show relatively low rates of edge rounding, with 87.2% showing no signs of post-depositional reworking.

The artefacts throughout the MGD-I deposit, but particularly in the denser stratigraphic layers, are characteristically MSA. Radial or discoidal reduction methods occur throughout, but are generally concentrated in and below layer BCS. Also present in BCS is a reasonably distinct reduction system featuring the unifacial radial working of small quartz crystal pebbles. The notable aspect of this kind of reduction is both the small size of the flakes produced, and the general absence of bipolar working. No typologically-regular implement types were observed. With ages placing this system ~22 ka, it may be considered a regionally distinct late MSA expression of great significance in understanding the transition of the MSA to the LSA across central Africa.

MGD-II

A total of 438 finds have been examined from MGD-II, of which 278 were determined to be artefactual. Again, these are mostly flakes (n=221), with reasonable representation of angular fragments (n=43) and small numbers of cores (n=8) and retouched flakes (n=6). Unlike MGD-I, MGD-II shows heavy signs of fluvial reworking. Only 42.8% of artefacts have no edge abrasion, while 14.5% have been abraded sufficiently that they can only just be discerned as having been artefacts.

As with MGD-I, MGD-II contains typically MSA artefacts including discoidal cores throughout, but also present are some potentially later markers including a Levallois point. Further work is required to differentiate the stratigraphic levels of the site and to test whether, within the general theme of reworking, intact or largely intact units can be identified. However, initial analysis suggests that these artefacts are part of a lag deposit overlying a recent channel that cut through the site ca. 15 ka {Wright, 2014 #6402}.

MGD-III

The recovered assemblage from MGD-III numbers 672 pieces, of which 573 were determined to be artefactual. Flakes account for 463 artefacts, followed in abundance by
angular fragments (n=76), cores (n=16) and retouched flakes (n=8). Overall, much of the assemblage appears to relate to the earlier Middle Stone Age, with large alternately-worked cores and discoidal cores present, along with many flakes with dihedral and faceted platforms. Also present, however, are two scrapers, a unifacial point, a backed artefact and some pieces of pottery. This, combined with the very low prevalence of unabraded artefacts (24.3%) suggests that the assemblage is extensively mixed and that very old and very recent artefacts may be present in similar levels. As with MGD-II, further work is required to assess the integrity of different stratigraphic layers, and to determined whether there may in fact be some partially or substantially intact layers in this part of the site. Preliminary analysis suggests that the majority of the artefacts derive from the same upper lag deposit that marks MGD-II – the “stony soil” of Kafulu {Kafulu, 1990 #5357}. Future work will focus on separating the characteristics of these from those of the artefacts recovered from the same palaeosol unit that yielded the elephant skeleton {Wright, 2014 #6402}.

Chaminadae III (CHA-III)

The analysis of CHA-III has so far been very limited, but does provide initial insight into the archaeological occupation of the site. The following points can be made:

- The site appears to include components from the Middle and Later Stone Ages
  - The latter includes backed artefacts
- Changes in material selection are gradual through the sequence.
- Flake platform size gradual increases with depth through the sequence
- The quartz rocks include pieces sourced from outcrops, differentiating the material acquistion pattern here from that at MGD

While assessments of the continuity of deposit accumulation at CHA-III remain to be developed, the sequence as it stands may plausible include a Middle to Later Stone Age transition, and also appears to contain one of the only significant, intact backed artefact-bearing assemblages so far recovered by MEMSAP – with the possible except of the deeply buried LSA assemblage from Test Pit 8.
Figure 51 Raw material change in the plotted finds from square C4 of CHA-III by context.

The age of the CHA-III assemblage will be of considerable interest, as will analysis of the nature of the potential transition at the site. This is particularly true considering the preliminary age estimates that potentially constrain the artefact deposition to between ca. 37 ka and ca. 57 ka – a relatively brief period of occupation, especially when considering that this period also encompasses ca. 3m of artefactually sterile sediment at the base. At the moment, with the limited amount of work carried out, CHA-III can be suggested as a site of considerable regional significance and one of the few open-air sites in Africa that potentially captures the MSA-LSA transition in situ. It is also notable that preliminary age estimates for three sites in the Karonga region (MGD-I, CHA-I, and CHA-III) have deposits with occupation dating to the period between ca. 44 - 37 ka.

VIII. SUMMARY
Summary and Conclusions

The 2013 field season undertook a range of activities designed to finalise investigation of key sites near the town of Karonga and prepare them for publication, whilst also paving the way for the next phase of MEMSAP research. All excavations proceeded on schedule and met the stated goals for sampling and artefact recovery. The effects of slope wash and bioturbation were characterised at the sites of CHA-III and CHA-IV, which will enable stronger interpretation of the OSL ages sampled from the profiles. At Bruce, site formation was further explored and the very small remnant of intact MSA deposit was identified near the BRU-II excavation.

The survey revealed more detailed patterns in MSA stone artefact reduction and raw material abundances. It also confirmed that although MSA materials are common in catchments north of the North Rukuru, they are not in situ. This is most likely because higher precipitation in the northern catchments has eroded previous Middle to Late Pleistocene alluvial fan deposits away and many MSA materials were deposited directly upon colluvium, pediments, or other non-aggradational surfaces.

In accordance with the timeline for research, several analytical tasks were also completed. These include stone artefacts, geoarchaeology, OSL, ochre analysis, and spatial analysis. Their completion allowed for submission of several manuscripts, four of which have been published or accepted within the 12 months since the last report. Preliminary OSL analysis reported here suggests that near the town of Karonga, alluvial fan deposition began prior to ca. 100 ka. However, MSA occupation does not appear in situ until ca. 63 ka, at the site of TP7. The adjacent site of CHA-III shows a rapid deposition of alluvial deposits, interspersed with MSA artefacts that transition into the LSA by ca. 37 ka. This is in contrast to other LSA materials recovered from MGD-I, in which LSA materials that retain an MSA character persist until ca. 22 ka. Across all sites for which we have ages to date, there is a clear clustering of MSA occupation in the region between ca. 45 – 35 ka. As this picture continues to unfold, we will be able to describe in detail how MSA behaviour relates to local periods of climatic change.

Future work will now focus on bringing together the last five years of fieldwork into a meaningful picture of the past, with more publications to follow. The majority of work
for this project phase near Karonga town is now complete. Future field seasons will include two components. One will be to investigate deposits outside the immediate proximity of Karonga town that are likely to contain older archaeological materials. These will begin with the site of Sadala South, where a handaxe was recovered in 2012 and where a cosmogenic nuclide depth profile is currently being produced that will aid in age control. The other will be continued survey and test-pitting at landscape and catchment scales, in order to better understand how MSA people moved about the region and what strategies they employed to mitigate the effects of severe climate change as recorded in the Lake Malawi sediment cores.

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IX. REFERENCES CITED


Appendix 1: Detailed sediment profile descriptions from sites investigated in 2013

Sedimentological descriptions of test pits excavated in the Karonga region were performed by David Wright and Flora Schilt between 25 July and 2 August 2013.

All sedimentary units were tested with 9:1 H₂O/HCl. Reactions to acid tests are reported below only if the sediments demonstrated a reaction. Additionally, all sedimentary facies were generally “poorly sorted” or “very poorly sorted” and so this descriptor is not included below.

Chaminade-III and -IV

Chaminade site sits on the shoulder of a steeply sloping ridge associated with alluvial fan deposition. The site is currently occupied by a single-family home, and agricultural fields extend across the site.

CHA-III: East wall profile

Unit 1: 0 – 8 cm. Fine to medium subrounded, spheroid pebbles (~25-30%) within a subangular to subrounded medium and very coarse sand (bimodal); unit is not found uniformly across the test pit; 2.5YR6/8; soft, friable, non-sticky, non-plastic; no bedding structures noted.

Unit 2: 8 – 100 cm. Poorly sorted subangular to subrounded medium to coarse sand; massive; 2.5YR6/8 (bottom), 10R5/8 (top); common Stage 0.5 redox (concentrations) appear as krotovinas; higher clay context toward the top of the unit on sediments; soft, friable, non-sticky, non-plastic; no acid effervescence; abrupt, smooth boundary.

Unit 3: 100 – 210 cm. Poorly sorted subangular to subrounded coarse to very coarse sand and very fine gravel; 2.5R5/8; inclusions of poorly sorted subangular to subrounded fine gravel (~40%) within poorly sorted angular to subangular coarse
sandy matrix (10R5/8); soft, friable, non-sticky, non-plastic; common insect, root, rootlets; abrupt, smooth boundary.

Unit 4: 210 – 215 cm. Poorly sorted, rounded to subrounded coarse gravels (~30%) and semi-discoidal to spheroidal, 8-12 cm diameter cobbles (2-5%) within a matrix of poorly sorted subangular to subrounded vert coarse sand and very fine gravel; 2.5YR5/8; hard, friable, non-sticky, non-plastic; few rootlets; no effervescence; abrupt, slightly wavy boundary.

Unit 5: 215 – 240 cm. Poorly sorted subangular to subrounded coarse to very coarse sand with 15-25% fine to medium subrounded gravel; 2.5YR5/8; common weathering feldspar; clear clay films on the gravels; common redoximorphic mottles; soft, friable, non-sticky, non-plastic; common roots, rootlets, and insect disturbances; abrupt, slightly wavy boundary.

Unit 6: 240 – 245 cm. Poorly sorted subangular to subrounded, semi-discoidal to semi-spheroidal medium to coarse gravel (25-50%) in a matrix of poorly sorted subangular to subrounded, semi-discoidal to spherical coarse to very coarse sand and very fine gravel; common, dispersed, weathering sand-sized feldspar; hard, friable, non-sticky, non-plastic; very slight effervescence; abrupt, broken boundary inclined 4° to the south and 5° to the east.

Unit 7: 245 – 270 cm. Fining upward sequence of poorly sorted subangular to subrounded coarse to very coarse sand and very fine gravel (lower, 10R5/8) to moderately well-sorted coarse sand (upper, 2.5YR5/8); very clear clay films in the lower portion of the unit; some dm-scale planar bedding structures in the lower part of the unit with abundant coarse feldspars; soft, friable, non-sticky, non-plastic; no effervescence; common roots, rootlets, and insect disturbances; abrupt, slightly wavy boundary.

*CHA-EXT: West wall profile*
Unit 1: 0 – 25 cm. Fine to medium sand with 25-50% subangular to subrounded, mixed sphericity coarse sand and fine gravel and 2-5% rounded to subrounded, mixed sphericity medium gravel; 2.5YR4/6; single-grain to weak massive structure; sift, loose, non-sticky, non-plastic; rare roots, rootlets and possible insect disturbances (casts?).

Unit 2: 25 – 40 cm. Fine to medium sand with 25-50% subangular to subrounded, mixed sphericity coarse sand and fine gravel; 2.5YR4/8; single-grain to weak massive structure; sift, loose, non-sticky, non-plastic; rare roots, rootlets and insect disturbances; abrupt, continuous boundary.

Unit 3: 40 – 185 cm. Fine to medium sand with 25-50% subangular to subrounded, mixed sphericity coarse sand and <1% fine gravel; 2.5YR5/8 (bottom), 2.5YR5/6 (top); horizontal cm-scale bedding structures are detected from ~+60 cm; soft, loose, non-sticky, non-plastic; rare roots, common rootlets and many insect disturbances (krotovinas); merging, continuous boundary.

Unit 4: 185 – 230 cm. Fine to coarse sand with mixed angularity; 7.5YR5/6; soft, loose, non-sticky, non-plastic; common roots, rootlets and insect disturbances; abrupt, continuous boundary; Ap horizon.

CHA-IV: North wall profile
The test unit is comprised of two intercalated sedimentary facies:

Unit 1: Slightly loamy sand with 25-50% coarse sand and 1-2% fine gravel of mixed angularity and sphericity; 2.5YR4/8; very weak, mm-scale bedding structures oriented -10° east > west; loose, soft, non-sticky, non-plastic; many roots, common rootlets, many insect disturbances.

Unit 2: Slightly loamy sand with 25-50% coarse sand to fine gravel of mixed angularity and sphericity; 5YR5/6; soft, loose, non-sticky, non-plastic; common roots, rootlets and insect disturbances.
Chaminade site exhibits heterogeneous preservation conditions of the sediments suggesting changing geomorphological aspect of the site over time. The basal sedimentation zone identified at the site in CHA-III is indicative of a fluvial channel, but since only 5 cm of the unit was exposed, this interpretation should be treated as provisional. The second phase of sedimentation is interpreted as alluvial fan deposition associated with Chitimwe Bed progradation. Chitimwe Beds are incised by two fluvial channel beds separated by 25 cm of channel bar sediments. Initial colluviation of the site is detected in Unit 4 of CHA-EXT, but is most obvious in CHA-IV, where there are numerous intercalated, dm-scale beds of reworked lateritic sediments and burned lateritic sediments. This is interpreted as occurring coincident to preparation of agricultural fields prior to planting when fields are burned, followed by rain. Rainfall washed unrooted sediments downslope depositing colluvium along the shoulders of fan ridges. Preservation of upper solum of CHA-III is inferred by the lack of bedding structures, lateritic soil development and coherency of the fining up sequence recorded in Unit 7. Therefore, while portions of the site are significantly disturbed and the archaeological facies within CHA-IV and upper 170 cm of CHA-EXT should be considered as secondary deposits, CHA-III and portions of the site extending south and west are likely intact.

“Rukuru River 1” site: South wall profile.
The depths of all units were recorded from the top of the profile. This unit was identified as an alluvial cutbank on the side of the Rukuru River. The site is an alluvial terrace (T-1) of the Rukuru River.

Unit 1: 200 – 150 cm. Loamy sand; 10YR4/2; massive to granular structure; common roots, rootlets and insect disturbances; hard, firm, non-sticky, slightly plastic; strong effervescence.

Unit 2: 150 – 115 cm. Sandy clay loam; 10YR5/3; granular parting to angular blocky structure; hard, firm, moderately sticky, moderately plastic; common roots, rootlets and insect disturbances; no effervescence; clear boundary.
Unit 3: 115 – 100 cm. Sandy clay; 5YR5/3; subangular blocky structure; hard, firm, moderately sticky, slightly plastic; common roots, rootlets and insect disturbances; no effervescence; clear boundary.

Unit 4: 100 – 70 cm. Sandy clay loam; 5YR4/2; angular blocky structure; hard, friable, slightly sticky, slightly plastic; no effervescence; clear boundary.

Unit 5: 70 – 5 cm. Sandy clay loam; 5YR3/1; subangular blocky structure; hard, friable, non-sticky, slightly plastic; common roots, rootlets and insect disturbances; no effervescence; gradual boundary.

Unit 6: 5 – 0 cm. Strongly mottled sediments with 15 – 25% fine to medium gravels; 5YR3/1; aggraded, unconformable on the A horizon; abrupt boundary.

Pedology of Rukuru 1 exposure: 0-5 Ap, 5-40 A, 40-70 Bw1, 70-100 Bw2, 100-150 Bt3, 150-200 Ck.

NOTE: Only a ~50 cm wide section was exposed from an alluvial escarpment of the Rukuru River. Therefore, determining the topography of the unit boundaries was not possible.

Chitipa-Karonga Road Trench: East wall profile.
This unit was a fortuitous encounter with a man who was digging a new latrine for his home. At the time of the visit, the unit was 175 cm deep, and there were no artefacts observed in the backdirt. The site was a fluvial terrace (T-2) of the Rukuru River.

Unit 1: 0 – 30 cm. Sandy clay loam; 7.5YR3/3; massive; hard, slightly friable, moderately sticky, slightly plastic; few roots.

Unit 2: 30 – 75 cm. Sandy loam; 7.5YR3/3; massive; hard, very friable, slightly sticky, slightly plastic; few roots; clear, continuous boundary.
Unit 3: 75 – 90 cm. Coarse to very coarse sand with 10-15% rounded to subrounded medium gravels; 7.5YR5/4; loose, very friable, non-sticky, non-plastic; abrupt, wavy boundary.

Unit 4: 90 – 130 cm. Sandy clay loam; 10YR4/4; blocky structure; hard, moderately friable, slightly sticky, slightly plastic; common roots and insect disturbances; abrupt, wavy boundary.

Unit 5: 130 – 175 cm. Sandy clay loam; 10YR3/2; granular parting to fine angular blocky structure; soft, very friable, moderately sticky, moderately plastic; common root, rootlet and insect disturbances; abrupt, continuous boundary.

**Pedology of Chitipa-Karonga Road Trench: 0-30 cm A, 30-70 Bw**

**Bruce site (BRU):** The site is located on steeply incised alluvial fan sediments and has significant modern settlement. Erosion is particularly acute in the southern portion of the site adjacent to the modern houses where vegetation has been cleared for agricultural fields. Two test units were excavated into the site in 2012 and were reexcavated in July 2013. Three 1-x-2 m archaeological test units (Areas I, II and III) were excavated into the artefact-bearing portions of the site. Additionally, a well was fortuitously excavated at the time the investigations were underway, so artefacts, OSL and micromorphology samples were collected from the profile walls and a sedimentological description was made of the stratigraphy.

**Area I: East wall profile**
Unit 0: 0 – 10 cm. Sandy clay; 2.5Y5/3; angular blocky structure; very hard, very firm, non-sticky, non-plastic; no disturbances noted.

Unit 1: 10 – 45 cm. Alternating cm-scale beds of rounded to subrounded, subdiscoidal to spherical coarse sand and fine gravel with clayey intraclasts (krotovinas?); 2-5% planar to subplanar beds of rounded, subprismoidal medium gravel beds; clast supported
matrix = 2.5YR3/6; few roots, common rootlets; very hard, very friable, non-sticky, non-plastic.

Unit 2: 45 – 55 cm. Basal bed of imbricated subrounded, subprismoidal to spherical fine to medium gravel fining up in wavy cm-scale beds dipping ~30° to the east, but appear subplanar/slightly wavy in the east wall profile; 2.5YR4/7; very hard, very friable, non-sticky, non-plastic; clast supported matrix; common roots, few insect disturbances; very abrupt, wavy boundary.

Unit 3: 55 – 70 cm. Fine gravel overlain by cm-scale beds of coarse sands and medium sands (fining up) dipping ~10° to the east, but appear subplanar/slightly wavy in the east wall profile; 2.5YR4/7; very hard, very friable, non-sticky, non-plastic; common roots, few insect disturbances; very abrupt, wavy boundary.

Unit 4: 70 – 95 cm. Basal bed of imbricated subrounded, subprismoidal to spherical fine to medium gravel (discontinuous) fining up in wavy cm-scale beds dipping ~30° to the east, but appear subplanar/slightly wavy in the east wall profile; 2.5YR4/8; very hard, very friable, non-sticky, non-plastic; clast supported matrix; common roots, few insect disturbances; very abrupt, wavy boundary.

Unit 5: 95 – 105 cm. Basal bed of imbricated subrounded, subprismoidal to spherical fine to medium gravel fining up in wavy cm-scale beds dipping ~5° to the east, but appear subplanar/slightly wavy in the east wall profile; 2.5YR3.5/6; very hard, very friable, non-sticky, non-plastic; clast supported matrix; common roots, few insect disturbances; very abrupt, wavy boundary.

Unit 6: 105 – 120. Basal bed of imbricated subrounded, subprismoidal to spherical fine to medium gravel (discontinuous) fining up in wavy cm-scale beds dipping ~5° to the east, but appear subplanar/slightly wavy in the east wall profile; 2.5YR3.5/6; very hard, very friable, non-sticky, non-plastic; clast supported matrix; common roots, many rootlets and few insect disturbances; very abrupt, wavy boundary.
Unit 7: 120 – 135 cm. Basal bed of imbricated subangular to subrounded, subdiscoidal to spherical fine gravel upon which an imbricated subangular to subrounded, subdiscoidal to spherical fine to medium gravel fining up in wavy cm-scale beds dipping ~5° to the east, but appear subplanar/slightly wavy in the east wall profile; 2.5YR3.5/6; very hard, very friable, non-sticky, non-plastic; clast supported matrix; common roots, many rootlets and few insect disturbances; very abrupt, slightly wavy boundary.

Unit 7A: (135 – 140: not present in west wall.) Basal bed of imbricated subangular to subrounded, subdiscoidal to spherical fine gravel fining up in wavy cm-scale beds dipping ~5° to the east, but appear subplanar/slightly wavy in the east wall profile; 2.5YR3.5/6; very hard, very friable, non-sticky, non-plastic; clast supported matrix; common roots, many rootlets and few insect disturbances; very abrupt, slightly wavy boundary.

Unit 8: 140 – 160 cm. Basal bed of imbricated subangular to subrounded, subprismoidal to spherical coarse sand to fine gravel fining up in wavy cm-scale beds dipping ~5-10° to the east, but appear planar in the east wall profile; 2.5YR3.5/6; very hard, very friable, non-sticky, non-plastic; clast supported matrix; few roots, many rootlets; very abrupt, continuous boundary.

Unit 9: 160 – 210 cm. Beds of dm-scale loamy sand and fine to medium sand with inclusions of fine gravel (5-10% in the loamy sand and 10-15% in the fine to medium sand); 2.5YR4/6; a 3-5 cm thick lens of imbricated, rounded to subrounded subprismoidal to spherical medium gravel comprises the base of the unit; many roots, rootlets and insect disturbances; very abrupt, continuous boundary dipping ~5-10° to the east.

Area II: South wall profile

Unit 1: 0-5 cm. Slightly loamy sand with 50-75% subangular to subrounded, mixed sphericity coarse sand and fine gravel and 5-10% subangular to subrounded, subprismoidal to spherical medium gravel; 2.5YR4/6; moderately hard, moderately friable; slightly sticky, slightly plastic; common rootlets.
Unit 2: 5-25 cm. Slightly loamy sand with 50-75% subangular to subrounded, mixed sphericity coarse sand and fine gravel and <1% rounded, spherical medium gravel; 2.5YR4/6; moderately hard, moderately friable, slightly sticky, slightly plastic; many rootlets; merging, continuous boundary.

Unit 3: 25-30 cm. Slightly loamy sand with 25-50% subangular to subrounded, mixed sphericity coarse sand and fine gravel with 15-25% rounded to subrounded, spherical to subprismoidal medium gravel; 2.5YR4/6; moderately hard, moderately friable, slightly sticky, slightly plastic; common rootlets; abrupt, continuous boundary dipping 2-4° to the northwest.

Unit 4: 30 – 135 cm. Loamy sand with 50-75% subangular to subrounded, mixed sphericity coarse sand and fine gravel and a wavy pebble stringer comprised of subangular to subrounded, subprismoidal to spherical medium gravels at +70 – 75 cm; 2.5YR5/6; MnO concentrations and masses are more prominent above the pebble stringer than in the underlying sediments; moderately hard, moderately friable, slightly sticky, slightly plastic; abrupt, continuous boundary dipping 2-4° to the northwest.

Unit 5: 110 – 200 cm. Mixed, gravelly Ap horizon; 2.5YR5/8; many roots, rootlets and insect disturbances; abrupt, wavy boundary.

Area III: South wall profile

Unit 1: 0 – 20 cm. Slightly gravelly sandy clay loam with 10-15% rounded to subrounded, subprimoidal to spherical coarse sand and fine gravel; matrix = 7.5YR4/4 and 7.5YR3/2 in areas with common MnO masses; massive parting to weak granular structure; very hard, very firm, very sticky, very plastic; rare roots, common rootlets; violent effervescence to acid test from western 2/3 of the unit with no reaction in the eastern 1/3 where laterite soil formation occurs.

Unit 2: 20 – 60 cm (west), 20 – 25 cm (east). Loamy sand and 50-75% subangular to subrounded, subdiscoidal to spherical fine gravel with 5-10% rounded to subrounded
subprismoidal to spherical medium gravel; loamy sand matrix comprised of redox
depletion (5Y6/3) and concentrations (2.5YR4/4); very hard, very friable, very sticky,
slightly plastic; clayey intraclast inclusions; rare roots, common rootlets; abrupt,
continuous boundary.

Unit 3: 60 – 63 cm (west), 20 – 23 cm (east). Lens of imbricated AB plane rounded to
subrounded, mixed sphericity medium to coarse gravel; the lens appears to be dipping
10° to the east in the north and south wall profiles, while slightly wavy, but 0° in the
west wall, while ~2° incline toward the south in the east wall, so the water flow
probably ran from the SW>NE; abrupt boundary.

Unit 4: 63 (west)/23 (east) – 75 cm. Loamy sand and 50-75% subangular to
subrounded, subprismoidal to subdiscoidal coarse sand and fine gravel (medium gravel
comprises <1% of the unit); 2.5YR4/6; very weak redoximorphic depletions;
moderately hard, moderately friable, slightly sticky, slightly plastic; rare roots, common
rootlets; abrupt discontinuous boundary.

Unit 5: 75 – 125 cm. Loamy sand and 50-75% subangular to subrounded, mixed
sphericity coarse sand and fine gravel with 2-5% rounded to subrounded,
subprismoidal to spherical medium gravel; 2.5YR5/6; moderately hard, moderately
friable, slightly sticky, slightly plastic; clay intraclasts related to root bioturbation; many
roots and rootlets especially between +100 and 125 cm; abrupt, continuous boundary.

Pedology of Area III: There is a well developed soil that appears at the top of Unit 4. The
soil may be decalcified in the upper solum, but it reaches Stage 3 (petrocalcic) Bk by -75
cm in the west of the test pit and -125 cm in the east. Some nodules in the Bw2 suggest
decalcification occurred.

**BRU-WELL:** Well for extracting water that was being excavated at the time
archaeological investigations were progressing at Bruce. The site is located in a valley
surrounded by alluvial ridges. Erosion of the topsoil appears to be significant in the
previous year resulting from clearing trees.
Unit 1: 0 – 25 cm. Clay parting to clay loam; (5Y5/4-w, 5Y7/3-d); very hard, non-friable, very sticky, very plastic; no disturbances noted.

Unit 2: 25 – 60 cm. Slightly sandy clay loam with abundant redoximorphic depletions (5Y4/3) and concentrations (2.5YR4/4); crumbly, platy structure; 2-5% coarse sand inclusions; hard, moderately friable, very sticky, very plastic; rare rootlets; abrupt, wavy boundary.

Unit 3: 60 – 80 cm. Coarse sandy clay loam with 10-15% angular to subangular prismoidal to subprismoidal fine gravels; 2.5YR5/4; numerous redox features; hard, moderately friable, very sticky, very plastic; no disturbances noted; merging, continuous boundary.

Unit 4: 80 – 90 cm. Fine to medium gravelly sandy clay loam; numerous redox depletions (5Y5/3) and masses (10R4/6); medium gravels comprise 10-15% of the unit and are rounded to subrounded, subprismoidal to spherical and the coarse sands and fine gravels comprise 15-25% of the unit and are rounded to subrounded, subprismoidal to spherical; hard, moderately friable, slightly sticky, slightly plastic; rare rootlets and roots; abrupt, continuous boundary.

Unit 5: 90 – 100 cm. Very coarse sandy clay loam with 2-5% subangular to subrounded, subprismoidal to spherical fine gravel inclusions; strongly weathered redox depletions (5Y5/3) and concentrations/masses (2.5YR4/6); Crumbly, granular structure; very hard, very firm, very sticky, very plastic; no disturbances noted; abrupt, continuous boundary dipping 10° to the west.

Unit 6: 100 – 105 cm. Coarse sandy clay loam with 15-25% fine gravels and 10-15% rounded to subrounded, subprismoidal to spherical medium to coarse gravels; strongly weathered redox depletions (5Y6/3) and concentrations/masses (10R3/6); sharp, non-abraded archaeological artefacts are discontinuously imbricated on the top of the unit.
boundary; the matrix is in a granular parting to fine blocky structure; very hard, very firm, very sticky, very plastic; no disturbances noted; abrupt, continuous boundary.

Unit 7: 105 – 120 cm. Very coarse sandy clay loam; moderate to strong weathered clay redox depletions (5Y7/2) and concentrations/masses (7.5YR4/4); crumbly granular parting to fine blocky structure; very hard, very firm, very sticky, very plastic; common rootlets; abrupt, discontinuous boundary (the unit is not present in the south end of the well and goes to +150 cm in the eastern portion of the well, while it is at +110 in the area where the micromorphological sample was taken (northwest corner).

Unit 8: 120 – 170 cm. Sandy loam with 10-15% very coarse sand; 2.5YR4/6; no redox noted, but the sediments are part of a laterite soil; soft, moderately friable, slightly sticky, slightly plastic; common roots, rootlets and insect disturbances; abrupt wavy boundary.

TP20: This geological test unit excavated in August 2012 and exhumed in 2013 was screened in 20 cm spits through 5-mm mesh. This test unit is located on an alluvial ridge and the adjacent area has been steeply incised.

Unit 1: 0 – 35/40 cm. medium to coarse sands and fine gravels with 5-10% subrounded medium gravels; the unit is heavily mottled with redox depletions (2.5Y7/2) and concentrations (10R4/6); massive; very hard, very friable, non-sticky, non-plastic; few rootlets.

Unit 2: 35/40 – 50 cm. Silty sand with 25-50% coarse fraction; the coarse fraction is comprised of rounded, subprismoidal to spherical coarse gravels (5-10% of total) with subangular to subrounded, subprimoidal to spherical fine gravels (25-50% of total); matrix = 5YR4/7, fine gravel = 2.5Y7/3; massive; very hard, very friable, slightly sticky, slightly to moderately plastic; no disturbances noted; abrupt, wavy boundary.

Unit 3: 50 – 65 cm. angular to subangular coarse sand to fine gravel with 15-25% rounded subprismoidal to spherical medium and coarse gravels imbricated
horizontally; the unit is heavily mottled with redox depletions (2.5Y7/3) and concentrations (10R4/4); massive; very hard, very friable, non-sticky, non-plastic; few rootlets; abrupt, wavy boundary.

Unit 4: 65 – 110 cm. Slightly loamy sand with 25-50% angular to subangular, subprismoidal to spherical fine gravels; the unit is heavily mottled with redox depletions (2.5YR7/3) and concentrations (2.5YR4/7); common consolidated MnO masses; massive; very hard, very friable, slightly sticky, slightly plastic; moderately few roots; abrupt, slightly wavy boundary.

Unit 5: 110 – 160 cm. Loamy sand parting to a sandy loam comprised of ~25% coarse sand and 15-25% angular to subangular, subprismoidal to spherical fine gravel; 2.5YR4/6; fewer redox depletion and enrichment zones compared to Unit 4; moderately hard, moderately friable, slightly sticky, slightly plastic; few to common roots and rootlets; clear, continuous boundary.

Unit 6: 160 – 225 cm. Sandy loam comprised of 15-25% coarse to very coarse sands; 10R5/8; laterite; no redoximorphic features noted; soft, very friable, moderately sticky, moderately plastic; common roots, rootlets, and insect disturbances; gradual, smooth boundary.

Unit 7: 225 – 280 cm. Sandy loam comprised of 10-15% coarse to very coarse sand; 10R4/8; laterite; soft, very friable, moderately sticky, moderately plastic; gradual, smooth boundary.

Unit 8: 280 – 290 (N)/300 (S) cm. Disturbed (Ap) horizon of gravelly sandy loam.

*TP21:* This geological test unit excavated in August 2012 and exhumed in 2013 was screened in 20 cm spits through 5-mm mesh. This test unit is located on an alluvial ridge and the adjacent area has been steeply incised.
Unit 1: 0 – 15 cm. Sandy clay; 2.5Y5/3; angular blocky structure; very hard, very firm, non-sticky, non-plastic; no disturbances noted.

Unit 2: 15 – 20 cm. Fine angular, discoidal gravel with 15-25% imbricated, rounded to subrounded medium gravels dipping to the southwest at 4-5°; 2.5Y6/3; very hard, friable, non-sticky, non-plastic; no disturbances noted; abrupt, continuous boundary.

Unit 3: 20 – 70 cm. Very coarse sandy clay; 2.5Y5/3; massive; strong redox depletions and concentrations (iron, goethite, manganese); hard, moderately friable, moderately sticky, slightly plastic; abundant artefacts noted in the profile wall; termite disturbances noted, but interpreted as occurring after excavation of the test pit; abrupt, continuous boundary.

Unit 4: 70 – 95 cm. Coarse sandy clay loam; 2.5Y5/3 with mottles of 10R 4/4; weak granular structure; hard, moderately friable, moderately sticky, slightly plastic; redoximorphic depletions are not as pronounced as in the underlying unit (Unit 3), but still prominent; few rootlets; clear, continuous boundary.

Unit 5: 95 – 155 cm. Medium sandy clay loam; 2.5Y5/2 with mottles of 10R4/4; granular structure; hard, moderately friable, moderately sticky, moderately plastic; common redoximorphic features (depletions and concentrations); common rootlets and insect disturbances; gradual, continuous boundary.

Unit 6: 155 – 270 cm. Sandy loam that fines up to a fine sandy loam; 2.5YR4/6; massive; soft, very friable, non-sticky, moderately plastic; laterite; few roots, common rootlets and insect disturbances; gradual, continuous boundary.

Bruce exhibits significant changes in sedimentology and pedology as viewed from the preserved stratigraphy indicative of regional shifts in climate and deposition. The early stage of deposition preserved at the site appears to have been lagoonal or wetland deposits illustrated by clayey units preserved in TP21, Area II and BRU-WELL. The lack of bedding features in the sediments and presence of sand fraction suggests that these
deposits were formed in small, hummocky marshes. The second stage of deposition is found in Area II and consists of sandy Chitimwe alluvial fan sediments. The Stage 3 pedogenic carbonate deposits indicate that period of landform stability within a generally arid climate ensued. A later prograding phase of alluvial fan deposition incised the topsoil and meandering streams truncated vast sections of the Phase 1 and 2 deposits. Aggraded beds of channel beds found in Area I as well as more diffuse lenses of gravel from TP20, TP21, Areas II and III and BRU-WELL evidence this transition. Later Chitimwe Bed deposition fined up and was less incised than during Phase 3. Redoximorphic weathering is common at the site, indicating water table fluctuations (TP20, TP21, BRU-WELL) as well as soil formation (Area II, Area III). Laterite formation within the sediments, likely associated with bioturbation, degraded bedding features that may have been present shortly after deposition. Modern agricultural activities have accelerated rates of erosion and exposed archaeological deposits on the ground surface.