MALAWI EARLIER-MIDDLE STONE AGE PROJECT

2014 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.

The 2014 field season represented the final year of MEMSAP’s first major project phase, which focussed on four main 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.

• **H5**: Northernmost Malawi became depopulated during Late Pleistocene megadroughts as lake levels shrank.

• **H6**: Permanent lakeshores in Malawi acted as population refugia during these megadroughts.

This report details the specific activities undertaken on the project in 2014 and early 2015, and provides a summary of where the project lies with respect to achieving these goals. As this phase of the fieldwork is now at a close, this report also outlines future plans for the next phase of research on the Stone Ages of Malawi.

**Summary of MEMSAP Activities to Date**

Most project activities have taken place in the Pleistocene Chitimwe Beds 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 9m$^2$). Kaufulu (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 2014 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 Secondary School (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.

Figure 1 Location of study area showing the distribution of MEMSAP excavations to date (yellow diamonds). Lake Malawi lies to the right and the geological overlay defines the boundaries of northern Malawi. Major river catchments are designated with black lines. Chitimwe Beds are red.

In 2010, test excavations were also undertaken at the northern site of Kafula Ridge West (in the Lufira river catchment) and at Mwanganda’s Village (Thompson et al. 2011). The 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 Kaufulu (1990) was not able to be 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 Kaufulu (1990) had not been conducted directly adjacent to the original Clark and Haynes elephant excavation. Instead, Kaufulu’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 in 2014 (Wright *et al.* 2014).

Also in 2011, two sites in the Chaminade area near the Karonga airport were excavated (Thompson *et al.* 2012b). The first, Chaminade I, yielded a small artefact assemblage upon which analysis was initiated in 2012. Phytolith analysis is currently being undertaken to complement the artefact analysis, OSL ages, and micromorphology results that are now finished from this site. 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. 2015).

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 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. The dating for the Area I assemblage was based on correlation with a test pit emplaced in 2010 approximately 12m northeast from the main excavation, and required support from additional samples from the profile itself. An OSL sample taken directly from the Area I profile in 2012 was found to be too small for measurement, and another yielded an age suggesting the assemblage was younger than previously determined. Thus, in 2014 this profile was re-exposed and new samples were taken (described in this report).

At the Chaminade II site in 2012, 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. An update on this work is provided in this report, and data recently presented at the annual Paleoanthropology Society meeting are in preparation for submission to a special issue of the *Journal of Archaeological Science* that focusses on tropical sediments.

Also in 2012, ten geological trenches were excavated in the southern catchments of the Karonga District to obtain data on the timing and processes of alluvial fan formation in the Chitimwe Beds. These included two additional cosmogenic nuclide burial profiles, which were sampled from geological trenches in river catchments south of Karonga (Ruasho and Wovwe). One of these was the site of Sadala South, which in 2014 was excavated more fully and is reported in more detail here. Cosmogenic nuclide dating samples from Chaminade II, Sadala South, and Wovwe Forks were to be processed at the Arizona State University WOMBAT laboratory, and then sent for measurement to the Australian Nuclear Science and Technology Organisation. However, following from major unexpected laboratory shutdowns in 2013, those samples are now in their final stages of processing and the revised anticipated date for obtaining measurement data and profile interpretation is September 2015.

Survey around the Karonga area in 2012 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. Two test pits around the Bruce site were also re-opened in 2013, sampled, and studied. In 2012 a collection of several thousand surface artefacts was fully plotted using total station, in order to assess site integrity and obtain a large representative sample of artefacts from the site. In 2014, this procedure was repeated to compare natural site modification over the course of two years. Results of this work were reported on a poster presented at the Society for American Archaeology annual meeting in 2015 and also presented here.

Also in 2012, a second “off-season” excavation was conducted; this time 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 southwest 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, along with a complementary step trench heading upslope and east-west from Test Pit 7 (Thompson et al. 2013a). The stone artefact assemblage was subjected to preliminary study by Dr. Alex Mackay in 2013 and 2015, and exported for further study at the University of Wollongong in Australia. All MEMSAP excavations have been fully backfilled, and with the exception of the recently exported CHA-III assemblage all artefacts exported by MEMSAP have been returned to Malawi.

Starting in 2012 and continuing to the present, MEMSAP has initiated a comprehensive survey protocol. 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. 2014a). An extension of this survey work was done in 2013 (Thompson et al. 2014b), during which time focus was made on surveying Chitimwe Beds to obtain a large sample of data from surface artefacts and cobbles. In 2014 this work continued, but now with an emphasis on understanding artefact distributions across different geology types. New results of survey in 2014 are reported here, and were presented at the annual Paleoanthropology Society meeting in 2015.
Summary of Project Outputs to Date

A summary of project outputs as of early 2014 is provided in Thompson et al. (2014b). New outputs and/or anticipated outputs since that date are as follows:

Conference Presentations and Posters


Outreach

1) “MEMSAP: Dispatches from the Field” is a blog maintained at http://www.memsap.org and linked to the project’s Facebook site at: http://www.facebook.com/#!/pages/Malawi-Earlier-Middle-Stone-Age-Project/257887127623607

2) Thompson, J.C. (July 2014). “A Morning of Public Archaeology”. Public lecture given at the Karonga Cultural and Museum Centre, Karonga, Malawi. This was part of a larger public outreach effort in collaboration with the Malawi Department of Antiquities and the Cultural and Museum Centre, Karonga. This event brings foreign researchers and students together with local community members and Malawi Government officials to learn about the rich archaeological record of Karonga and how to responsibly manage and learn from it.

Education and Training

In 2014 four representatives from Malawi Department of Antiquities (soon to become Monuments and Museums) joined in MEMSAP fieldwork. Three of these people, Mr Malani Chinula, Mr Federick Mapemba, and Mr Joseph Tembo, had previously been engaged in field and lab work. Mr Medson Makuru joined for the first time in 2014, also taking part in the 2014 Archaeological Field School run through The University of Queensland (UQ). This was the third iteration of the UQ version of the course, which has provided training for both Australian and Malawian students alike, whilst also imparting essential experience to heritage workers in Malawi. Lastly, two volunteers from England (Ms Sarah Peel of Oxford University and Mr Tomos Evans of the University of Cambridge) assisted with fieldwork and also gained experience whilst doing so.

Summary of 2014 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, Thompson et al. 2014b). MEMSAP activities in 2014 fell into ten 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>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Obtain two new OSL samples and a new micromorphology sample from Mwanganda Area I.</td>
<td>Re-open the most heavily-sampled portion of the southern profile to obtain and map the samples.</td>
</tr>
<tr>
<td>2</td>
<td>Test the potential for the eroded area at BRU to be the same site as the original Clark (1965) Chaminade 1A excavation.</td>
<td>Open and describe three geological trenches from the eroded area.</td>
</tr>
<tr>
<td>3</td>
<td>Determine how much artefact movement has taken place over two years of exposure at BRU.</td>
<td>Complete surface collection of artefacts within the same gridted area from which artefact were surface-collected in 2012.</td>
</tr>
<tr>
<td>4</td>
<td>Assess how core technology, artefact abundances, lithic raw materials, and ochre sources vary across different geology types from the lakeshore to the highlands.</td>
<td>Transect surveys of major river catchments draining across the Chitimwe Beds, with more strict attention to sampling different geology types.</td>
</tr>
<tr>
<td>5</td>
<td>Assess the sub-surface archaeology of geological surfaces in the highlands, for comparison to the alluvial plain sample.</td>
<td>Emplacement of 2 archaeological test pits in the Chegama area to the west of Sadala South.</td>
</tr>
<tr>
<td>6</td>
<td>Assess the geomorphology and sub-surface archaeology of the Sadala South area, with specific aims to sample older artefact-bearing deposits.</td>
<td>Emplacement of 17 archaeological test pits around the perimeter of the Chitimwe Beds preserved in the Sadala South area.</td>
</tr>
<tr>
<td>7</td>
<td>Obtain a spatially-controlled sample of artefacts, dating samples, and environmental samples from the Sadala South site near the 2012 geological trench in the area.</td>
<td>Excavation of a 5 x 7m area of intact sediment near the 2012 geological trench at the site of Sadala South.</td>
</tr>
<tr>
<td>8</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>9</td>
<td>Continue analysis of stone artefacts and samples and move the results towards publication.</td>
<td>Continued analysis of stone artefacts and samples, with a focus on comparison between the Karonga and Sadala test pit samples.</td>
</tr>
<tr>
<td>10</td>
<td>Prepare results to date for publication</td>
<td>Manuscripts in preparation for submission 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, continued accumulation of empirical evidence in northern, 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) – including complex tool manufacture, long-distance exchange networks, and symbolic behaviour (Parkington et al. 2013, Nash et al. 2013, Henshilwood et al. 2011, Henshilwood et al. 2014)

The MSA was a time period that ranged between ca. 50 – 280 thousand years ago [ka] in east Africa (Tryon et al. 2005, Tryon and McBrearty 2002, Tryon and McBrearty 2006, Eren et al. 2013), but possibly started as early as ca. 500 ka and ended as late as 20 ka in southern Africa (Porat et al. 2010, Wilkins et al. 2012, Clark 1997). 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, Blome et al. 2012, Mackay et al. 2014). 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, Thompson et al. 2014b).

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. In addition, since the time of their initial deposition MSA sites have 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 0.5-1 mm/yr in the western branch of the EARS (Einsele 1996), and average sedimentation rates in the Lake Malawi basin are estimated at ~1 mm/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 into 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, Lüdecke and Thiemeyer 2013). 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. 2014a, Clark 1966).

The abundant MSA record of northern Malawi received its first detailed attention in the 1960s from J. Desmond Clark and colleagues (Clark 1966, Clark et al. 1966, Clark et al. 1970, Clark and Haynes 1970). The exposures reported from near 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 them (Clark 1966, Clark 1968, Clark et al. 1967, Clark et al. 1966, Clark 1972, Clark and Haynes 1970).

Figure 2 Map of Malawi (left) showing the two lake core drill sites within the modern lake (light blue) and relative to the lake at is maximum reduction during megadrought periods (dark blue). A close-up of northern Malawi (right) shows Karonga town (star) in relation to locations of Chitimwe Beds (red). Topography is based on ASTER data (a product of METI and NASA), with darker colours lower and lighter colours higher.

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). It is within the framework provided by this body of geological and palaeoclimatic work that the primarily archaeological objectives of MEMSAP are carried out.
II. 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.

Survey in 2014 built on pilot work from 2012 and 2013 of a series of major river catchments in Karonga (Thompson et al. 2014a), specifically by developing a new systematic sampling protocol for understanding the distributions of different types of stone raw material availability and lithic reduction across the various geologic units exposed in northern Malawi. This new strategy consisted of completion of multiple transects across the landscape of Northern Malawi, with each transect crossing in a straight line a range of geological exposures and only recording those objects that were encountered upon this line.

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). The lower reaches of the northern three catchments
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 catchments of the northern rivers (Songwe, Lufira, and North Rukuru) compared to the southern rivers. Darker blue shading indicates more precipitation. Red is Chitimwe Beds, grey is Chiwondo Beds, and orange is Dinosaur Beds. Precipitation data are from Hijmans et al. (2005).

In contrast, the southern landscape comprises many smaller catchments where the majority of cobbles are small, medium-quality quartz (Thompson et al. 2014a). South of Karonga town, rainfall plateaus 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). 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. Thus, the survey methods are designed to investigate the distributions and attributes of lithic raw materials and stone artefacts in order to better understand how these landscape differences affected Stone Age foraging patterns.

One obstacle to making these comparisons is preservation. The Chitimwe Beds represent Pleistocene alluvial fan systems that contain MSA sites, but they are unevenly preserved across the landscape. Generally speaking, the northernmost catchments preserve the smallest remnants of these deposits, while larger deposits have been preserved in the south by a combination of lower overall precipitation, lower gradient, and the presence of nearshore bedrock that serves as a barrier for the accumulation of sediment and a mechanism for preventing subsequent erosion (Figure 3). One other item of note is that the Dinosaur Beds are the most likely source material for the deposition of the Chitimwe Beds. These are also strongly eroded in the north and better preserved in the south, although near the town of Karonga the conglomerate Sungwa Beds (possibly a younger facies of the Dinosaur Beds) offer the opportunity for exploitation of large, high-quality quartzite cobbles not preserved in such abundances elsewhere in Karonga.

**Methods**

In 2014, a new recording system was implemented that was entirely digital, using tablets with a built-in camera that were running a custom-made archaeological recording software designed under the auspices of the Federated Archaeological Information Management System (FAIMS). Although many of the same attributes were recorded as was done in previous surveys (Thompson et al. 2014a), FAIMS was used to catalogue the data recovered in the field more efficiently, with the intention of also minimising human data entry errors. An outline of the tab structure and data entry parameters is provided in Appendix 1.

The 2012 and 2013 survey had concentrated on exposures of the Chitimwe Beds, in order to obtain data from a large sample of stone artefacts and lithic raw materials for analysis. Also in the 2012 and 2013 work, data recording only focussed on cores, rather than also including the abundant flakes that also occur across the landscape. In designing the 2014 survey, two main approaches were used that modified these previous methods. First,
River catchments were defined in ArcGIS using ASTER Digital Elevation Model (DEM) data as well as digitised data from maps obtained from the Malawi Geological Survey. It was understood that the mouths of catchments where rivers were less deeply incised (especially on the floodplain immediately adjacent to Lake Malawi) may have had different spatial distributions during the Middle Stone Age; thus, survey lines were defined by interpolating a straight line to the shore starting from the basement geology exposed further up deeply incised catchments (Figure 4).

Figure 4 Map of northern Malawi showing the pathways of survey tracks in 2012, 2013, and 2014. Note the linear nature of the 2014 tracks. Black lines represent catchment boundaries.

Each survey line began along the floodplain as close as possible to Lake Malawi and ended when it either crossed into a new water catchment area, arrived at the end of the geological areas of interest, or where the landscape was such that surveying on foot was no longer a safe option. In all but one case, the transects had to be stopped due to terrain becoming too dangerous to continue; these instances were also usually associated with areas that contained extremely low amounts of archaeological evidence. Because the survey team comprised three people but with two maintaining the survey line (Jacob
Davis and a combination of either Andrew Zipkin, Davie Simengwa, or Frederick Mapemba), the visual survey path could be considered to be approximately 6 m wide.

During the survey, each change in geology and landform resulted in a change in recording, designated as a new “transect”. Within each section, all artefactual cores were recorded for their attributes, and the same was done for a sample of 10 cobbles (if available). The second major modification to the 2012 and 2013 strategy was that, alongside the core and cobble analysis, a 4 m² “total recording” sample was taken every 100m along the designated transect line. These areas would receive full recording of all artefacts > 2cm in the maximal dimension that they contained, rather than emphasising only cores (Figure 5). After recording and photographing them, all artefacts were placed back in their original positions.

Figure 5 Map of the two northernmost survey lines from 2014 relative to major geological units of interest, MEMSAP excavations (from all years), and showing which total recording points contained artefacts.
Along a portion of the first transect, an Unmanned Arial Vehicle (UAV) was used to take aerial photographs of a portion of the first transect in order to better relate the archaeological evidence to elevation models created using photogrammetric analysis called Structure from Motion (Westoby et al. 2012). Unfortunately, the UAV malfunctioned after a few attempts and was destroyed, so that only a small amount of usable data were able to be recovered. These included full aerial survey of Mwanganda’s Village, part of the Sadala South and Chaminade II sites, and the eastern portion of the Ruasho survey line.

Results

Landscape Survey

The Survey consisted of four main transects, each of varying distances and also each covering different water catchment areas that each run roughly west to east: the North Rukuru, the Ruasho, the Remero, and the Nyungwe (Figure 6).
Transect 1

Transect 1 ran through the Ruasho catchment south of the main town of Karonga. The survey completed 5 km of continuous survey, with complete recording done every 100 meters. This transect was deliberately aimed to skirt along the Chiwondo/Chitimwe deposits that were being concurrently investigated through subsurface excavations as part of the 2014 research program. For the first time, deposits several km west of Lake Malawi were surveyed along a transect continuous with one that covered the better-known lacustrine and alluvial Chiwondo/Chitimwe Beds. In the foothills behind the alluvial deposits, a wider range of raw materials was found than was typical of the quartz and quartzite materials found in association with the Chitimwe MSA. These included mudstones, large chert nodules, and shales that are easily flaked. In spite of its workability, no archaeological evidence could be seen for their use. Preliminary observations of the attributes of artefacts found along this transect suggests that away from the lake and other nearshore water sources, lithic technology becomes simpler. This was found to be true across all survey lines, with a significantly greater proportion of single-platformed cores than other cores in the recordings that were performed in the foothills versus on the alluvial plain (Fisher’s Exact Test p = 0.0155). Fewer flaked stone artefacts overall were found on the inland side of the foothills, which created a natural barrier and may have discouraged exploitation by roving bands of hunters. An alternative hypothesis is that these areas were used, but the depositional environments there do not promote site preservation.

Transect 1 was the only transect that had the use of the UAV system (Figure 7). Approximately 400 metres of survey area was covered with the UAV system, photographed, and catalogued with GPS data for map reconstruction and a resolution of ca. 5 cm. The photographs taken did in fact give view to a dynamic geological area, with Chiwondo and Chitimwe deposits as shown on coarser-scale geological maps. Ground-truthing along the transect showed that some of these deposits contained a high abundance of lithic artefacts exposed on the surface, while subsurface artefacts were also revealed through excavations taking place in the area.
Figure 7 The quadcopter UAV flying and some of the Structure from Motion models that were rendered from the photographs it took. Top: view west along part of a survey line. Bottom: view north along the same line.

Transect 2

This transect covered the known archaeological area around the Karonga Airport, and headed west, ending next to an area called Wilangi, which is considered to be of high cultural significance to the local people. This survey at completion was 7.45 km long, taking place primarily in the North Rukuru catchment and ending where it curves and adjoins the next catchment area. This transect covered a wide range of landform types, yielding pockets of Middle Stone Age archaeological material.
As was found in the first transect, raw material types not common to the lower catchments but excellent for flaking were found in higher abundances beyond the foothills and – in this case – within the boundaries of the second catchment area. Few lithic artefacts found on the surface were made using these finer grade materials. Although this transect was the longest, it did not contain the most archaeological evidence. Most archaeological materials were below the foothills, which were heavily concentrated on their lower slopes with cobbles. This also made spotting artefacts in the hills more difficult. As the foothills were generally either part of a reserve forest or a conservation area, leaf litter and grasses were abundant that could have been covering possible artefacts. One observation was that cores seemed to be distributed on the edges of geological units from which they had likely eroded long before. For example, there was a large concentration of them just below the bedrock started, at the most proximal portion of the alluvial fan and where it had become mixed with Holocene and other more recent sediments (Figure 8). Thus, although there appear to be many artefacts here, they are not likely to be in situ and suggest a more extensive ancient distribution of MSA materials that have been subsequently eroded. This transect was also notable because a possible ochre source of large boulders from the Dinosaur Beds was seen.

Figure 8 Elevation profile of the North Rukuru survey line showing the different geological units that were traversed and the locations of cores upon them.
Transect 3

This transect was located in the catchment of the Remero River and covered 2.87 continuous kilometres. Even though there were some archaeological deposits, they were relatively scarce compared to Transects 1 and 2. The terrain quickly moved into foothills that were too steep and dangerous to allow further reconnaissance. An attempt was made to circle around the foothills and continue the transect from the other side, but it could clearly be seen that the section of the transect that couldn’t be completed was too dangerous to attempt on foot.

Transect 4

The fourth transect was on the north side of the Nyungwe River catchment and covered two discontinuous parts, 2.7 km, followed by a 3.6 km gap, and another 0.3 km survey path on the same heading. This area had a longer gradual slope or apron preceding the foothills, with erosions and exposures showing areas with archaeological evidence and interest to the project – although the exposures closer to Karonga had heavier clusters and concentrations of lithic artefacts on the landscape. Unfortunately, the foothills here were also too dangerous to attempt in a straight line along the same transect. An identifiable road continued around the foothills and met up with the end of the fourth transect, which terminated on a mapped Chitimwe deposit that had never previously been explored for archaeological purposes. The walk up to the Chitimwe deposit on the transect line was unstable and too dangerous to remain on track, but goat paths and logger trails assisted in the climb to the top. Once the top had been reached, a small remnant of Chitimwe Beds was confirmed approximately 80 m above the Nyungwe river system.

An initial survey of the formation revealed actively eroding archaeological sites of apparently intact nature, suggesting high scientific significance and potential to inform about past human behaviour. In at least two instances, the artefacts represented what appeared to be well-preserved knapping floors dominated by artefacts of matching raw materials and arranged in a U-shape, as though they had been distributed around a seated person. There were also several instances of rare and high-quality raw materials such as silcrete and crystal quartz. Unfortunately, the survey and total collection data do not
reflect the significance we have inferred for this formation and the archaeology within it. Archaeological occurrences appeared to be most intact towards the south end of the deposit, protected by more sediment than at the north end. Any archaeological occurrences not appearing on the surface would not have been recorded on the transect, and the 100 m spacing of the total collections was too wide to capture in detail the distributions of sites in this remnant piece of the Chitimwe Beds. The area is not only intact, but also under immediate threat, as is apparent from the very steep and quickly eroding nature of the deposits (Figure 9).

![Figure 9 Very steep Chitimwe Bed remnant (left) with intact archaeological deposits that may represent knapping floors (middle) and which are under immediate threat of erosion (right).](image)

**Discussion and Recommendations**

The total number of metres walked and cores found is summarised in Table 2.

**Table 2** metres walked along each geology type in each catchment (m) and the number of cores found along each (C).

<table>
<thead>
<tr>
<th>Geology Type</th>
<th>North Rukuru</th>
<th>Nyungwe</th>
<th>Remero</th>
<th>Ruasho</th>
<th>Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>m</td>
<td>C</td>
<td>m</td>
<td>C</td>
<td>m</td>
</tr>
<tr>
<td>Alluvium/Dambo</td>
<td>1459</td>
<td>2</td>
<td>346</td>
<td>0</td>
<td>594</td>
</tr>
<tr>
<td>Biotite Gneiss with Amphibolite Dykes</td>
<td>4405</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>1321</td>
</tr>
<tr>
<td>Chitimwe Beds</td>
<td>2602</td>
<td>3</td>
<td>1741</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chiwondo Beds</td>
<td>1039</td>
<td>5</td>
<td>3820</td>
<td>2</td>
<td>2865</td>
</tr>
<tr>
<td>Dinosaur Beds Lakeshore/River Alluvium</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>250</td>
<td>0</td>
</tr>
<tr>
<td>Quartzite</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sungwa Beds</td>
<td>953</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Although it was found that there are significant differences between core reduction in the foothills versus the floodplain, these differences were not incremental. Spearman’s Rs did not find any significant correlations between distance from Lake Malawi (in 500 m bands) and number of scars, flaking on the perimeter, and the percentage of remaining cortex. There were also no significant correlations between these distances and the number of cores, their weight, nor the percentage that are made on quartz versus other materials. However, distance from the lake is a very gross measure and it is likely that more detailed analyses that also incorporate the 2012 and 2013 data will show more robust results. Example artefacts that were recorded over the course of the survey are shown in Figure 10.

In future work, the remnant Chitimwe Bed deposit in the Nyungwe catchment should be revisited and mapped in more detail. As many intact deposits are preserved, potentially including knapping floors, it is also highly recommended to conduct subsurface test-pitting using a total station and piece-plotting for more detailed artefact spatial data recovery. This site also has geological significance in that it lies far to the west of Lake Malawi, as well as further south than any other MEMSAP subsurface investigations to date. Thus, it will provide the ideal complement to existing data and aid in understanding the distribution of human behavioural strategies across the wider Middle Stone Age landscape. In the course of survey, ochre sources, possible raw iron formations, and water springs were also found, suggesting that some resources extending back to MSA times and still present on the landscape and can be examined with respect to their relevance for past behavioural interpretations.

Figure 10 Examples of artefacts found during survey. Left: a core-on-flake was relatively rare; Middle: a radial core on quartzite was a typical discovery diagnostic of the MSA; Right: raw materials such as crystal quartz were rare but present.
The survey also served as a test case for the use of a UAV in this context. It was initially difficult to set up and fly the instrument so that it took continuous, clear, and undistorted aerial photographs of an area of interest. However, after receiving support from the manufacturer, some aerial photography was obtained and in addition to the 3D models, these offer additional clarity for understanding the excavated sites in their landscape contexts. Unfortunately, owing to a manufacturer glitch, the UAV crashed and became irreparable. Thus, much was learned about the model and manufacture specifications that must be deployed in future use, the utility and promise of this method has now been demonstrated for future seasons.
III. EXCAVATION

Overview and Rationale

There were five major excavation goals for the 2014 fieldwork: 1) Emplace a new excavation at the Site of Sadala South, near where a handaxe was recovered in a geological test pit in 2012 2) Emplace seventeen new test pits around the perimeter of exposed Chitimwe Beds in the Sadala South area, to provide context for the main excavations; 3) Emplace and describe test pits along the survey transects to pair surface with subsurface artefact distributions and attributes; 4) Emplace geological trenches upslope of the Bruce (CS-70) site to confirm if it was the location of a previous archaeological excavation, potentially led by J. Desmond Clark in 1965; and 5) Take one additional sample from the Mwanganda Area I site to augment OSL analyses that could not be completed for a layer of interest because the first attempt at sampling resulted in too little material to produce an age.

The Sadala South excavations were targeted because in 2012 a 1 x 3 m geological trench was emplaced in this area, approximately 6 km south of Karonga, in a remnant island of Chitimwe Beds. It was sampled for cosmogenic nuclide dating, OSL, and micromorphology (Thompson et al. 2013a), but because the main purpose was to obtain geomorphic data from several different Chitimwe surfaces exposed in Karonga, the trench was not excavated archaeologically. Several artefacts unearthed fortuitously during its emplacement in 2012 were collected from the backdirt, including an unweathered, finely worked chert handaxe. This site therefore shows the clearest evidence for an Acheulean occupation of

Figure 11 Chert handaxe recovered from the Sadala South trench (at rear, ca. 3m deep).
the Karonga region. Of the 98 artefacts recovered (6 from the upper unit, 92 from the lower unit), it is known that the handaxe was found at below 2.5 m depth in the trench. The formal excavations undertaken in 2014 were in part designed to better understand the age, sedimentary context, and archaeological associations of the handaxe, but also targeted at obtaining a carefully-excavated sample of intact MSA artefacts from a Chitimwe remnant further south of where most formal excavations had previously taken place.

Of the five main excavation activities listed above, 1 – 3 are outlined in this section, with results from the test pits described in further detail in the sections on geoarchaeology and lithic analysis. Activities 4 and 5 are described purely in the section on geoarchaeology. The distribution of all subsurface activities in 2014 is shown in Figure 12.

![Figure 12 Locations of the main localities where excavations took place in 2014. Green circle in inset is the Sadala South I main site. Base image from Google Earth.](image-url)
**Methods and Protocols**

**Sadala South**

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, and orientations were taken on artefacts with a long axis to determine the nature of any post-depositional movement (McPherron 2005, Bernatchez 2010). Context opening and closing shots were also taken using the total station, and the elevations manually re-entered into the context forms to ensure each one was fully closed before moving to the next. 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.

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 2014 excavations were backfilled using the residue that had passed through the screen. All standard MEMSAP laboratory procedures and site locations are detailed in Thompson et al. (2013a).

Before beginning at Sadala South, five control points were established around the proposed excavation area. An Ashtech Promark 800 differential GPS was used to establish them, initially without post-processed results. After establishing CP150 and CP154, all other control points were shot in using the total station only. Later in the season the base station was set up over CP154 for eight hours of static processing, which when post-processed using AUSPOS was found to be within a metre of the original northing and easting values and only five metres lower than the non-post-processed elevation. In order to make subsequent landscape work match the data from Sadala South, CP154 was localised to its original coordinates and used as a baseline for recording spatial data for
the test pits and the larger landscape. The coordinates for these control points are provided in Table 3.

Table 3 Coordinates (UTM Zone 36L WGS84 Datum) for all SS-I control points.

<table>
<thead>
<tr>
<th>Name</th>
<th>Easting</th>
<th>Northing</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP150</td>
<td>599158.335</td>
<td>8894219.020</td>
<td>552.640</td>
</tr>
<tr>
<td>CP151</td>
<td>599182.003</td>
<td>8894205.097</td>
<td>554.400</td>
</tr>
<tr>
<td>CP152</td>
<td>599145.730</td>
<td>8894198.550</td>
<td>554.953</td>
</tr>
<tr>
<td>CP153</td>
<td>599137.073</td>
<td>8894217.407</td>
<td>554.244</td>
</tr>
<tr>
<td>CP154</td>
<td>599185.850</td>
<td>8894236.490</td>
<td>555.146</td>
</tr>
<tr>
<td>CP154*</td>
<td>599185.415</td>
<td>8894237.477</td>
<td>550.144</td>
</tr>
</tbody>
</table>

*8 hours of continuous static reading post-processed through AUSPOS and then converted from geodetic to grid.

The localised data were found to be systematically about 2 cm different in the easting and 4 cm different in the elevation from the coordinates provided in Table 3, so a similar margin of error may be supposed for all other test pit data. After localisation, the roving part of the differential GPS was walked around the landscape to collect elevation data at intervals of 5 m. When a test pit was reached, the unit was steadied and the corners (top and bottom) of the pit were mapped more precisely. All samples (micromorphology and OSL) from the test pits were also mapped using the differential GPS, so that they should be comparable at a high level of resolution to the data from the main Sadala South excavation.

The excavation area comprised a grid of 1 x 1m squares about 12 m SW of the 2012 geological pit from which the handaxe had been recovered. Although based on UTM coordinates, an alphanumeric system with letters increasing to the east and numbers increasing to the south was used to name the grid. For example, the second square in the first row would be named B1. The grid measured 5 x 7m, with corners placed according to a true coordinate grid based on CP150 and CP154. Excavation began with Square C3, in case any minor extensions needed to be made to the north or the west. A map of the site layout is given in Figure 13.
Figure 13 Layout of the Sadala South I (SS-I) main site, showing square designations, the locations of CP150 and CP154, and the location of the 2012 geotrench (red rectangle). Deeper units have darker shading. The pit in the bottom right of the image was excavated by the landowner for a new latrine and artefacts could be seen in the backdirt.

The site of the original 2012 geological trench was re-located but not re-exhumed. Excavation proceeded by natural layers or arbitrary spits, whichever was reached first. The geological pit excavated in 2012 had demonstrated that the upper layers – comprised mainly of fine-to-medium reddish sand – contained few artefacts. Therefore, spit thickness in this depositional unit was designated as 20 cm. Where artefacts began to become more abundant, spit thickness was changed to 10 cm and then eventually 5 cm, although in the most artefact-rich layers most context changes took place according to thin natural depositional units. Spit thickness was a variable recorded for each context.

Daily spatial data collected with the total station were cleaned in MS Excel on a daily basis and uploaded into an interactive ArcGIS database to check for spatial errors and patterns. During excavation, a bulk sediment sample was taken of each context as it was opened, and kept as an archive. After excavation, sediment micromorphology, OSL, pollen, and
phytolith samples were taken from the north and east profiles and mapped using the total station. Stratigraphic sections were described, and also photographed and drawn by hand and with the total station.

In addition to piece-plotting artefacts, each spit, layer, or feature was designated as a context and the geological and archaeological characteristics of each context (including sedimentary attributes, photographs, disturbances, samples, and elevations) were recorded using a custom-designed MEMSAP Excavation Module created by FAIMS and recorded directly into Samsung Galaxy 3 tablets running the Android OS platform (and with photographs taken using the on-board camera). The FAIMS product mirrors the standardised project context forms that have been used since 2010, but eliminates the possibility of transcription error since all data are directly entered in digital form in the field. However, there is still a possibility that data may be mis-entered. Therefore, the software includes controls on what must be entered before a context can be closed and it also saves a history of every change (and the person who makes each change). At the end of each day the tablets were turned on to sync back at the MEMSAP field lab so that they could exchange and update all their data with one another and with a local server equipped with a ruggedised backup hard drive set for automatic backups. The server had no internet access but rather was the host for a local, private network connection. As the FAIMS product was new and tablet quantities were limited, the more familiar paper context forms were used for all test pits, scanned as a digital archive, and their data manually transferred into an Access database. Detailed recording and total station protocols are provided in Thompson et al. (Thompson et al. 2012b).

Test Pits

Test pit locations were selected according to several criteria. They were meant to provide approximately equal coverage of the main Chitimwe deposit that remains at Sadala South, so that the subsurface distribution of artefacts and geological facies could be assessed. They were spaced approximately 300 m apart from one another in a roughly circular configuration around the shoulders of the Chitimwe Beds (Figure 14).
The shoulders of the Chitimwe Beds were targeted because erosion has proceeded naturally underneath the loose, sandy (and apparently sterile) overburden that caps the Chitimwe Beds and is called in some places the Karonga Formation. Specific locations for the test pits were determined through pedestrian survey with handheld GPS, which identified locations upslope of where artefacts appeared to be eroding directly from the sediments, and where cordial relationships with the local landowners could be established. For each test pit, a 1 x 2 m excavation area was gridded out running approximately N-S, and this was excavated as a single context unless there was a change in natural stratigraphy. Every attempt was made to follow natural stratigraphy, and where this was not possible the sediment was removed in arbitrary 20 cm spits. All sediment was passed through a 5 mm dry screen and all artefacts collected in bulk according to context.

Results

Sadala South I (0599170mE 8894218mS)

Sadala South I (SS-I) is located near a house surrounded by agricultural fields (Figure 15).
The elevation as measured by DGPS is 554m, but with the post-processing correction should be 549m. The ASTER DEM data also provide a value of 554m, but it is notable that the elevation given on Google Earth Pro’s terrain option is 570m. In this case, the corrected DGPS reading is the most reliable, but it does show the potential spread of values. DGPS mapping and review of ASTER data also show that this remnant of Chitimwe Beds is poorly mapped on the geological maps, as it extends up to 1 km farther to the west than is mapped. This was observed when the site was discovered, and it is the reason that SS-I appears on the maps within the Chiwondo Beds when in fact it is on an eroding shoulder of Chitimwe alluvial fan sediments. This discrepancy is apparent in the elevations as seen when the ASTER DEM data are compared to the distribution of the mapped Chitimwe Beds. The much finer resolution of the DGPS-generated map shows the same pattern, but with a pixel size of 1m rather than the 30m of the ASTER data (Figure 16).
Figure 16 Comparison of the ASTER DEM data and the DGPS-generated elevation data. Note the mismatch between the mapped Chitimwe Beds (black outlines) and the elevation data. Most other Chitimwe Bed remnants are mapped more accurately.

The stratigraphic sequence at SS-I is similar to that recorded from the geological trench, in that a thick series of alluvial sands overlie a distinct cobble horizon approximately 10 cm thick, which is then underlain by stringers of coarser and finer alternating and merging sands (Figure 17). However, it is not similar in that no distinct iron nodule layer was observed in the SS-I excavation, and this was a salient feature of the 2012 geotrench profile only 12 m to the northeast. Further information about our ability to correlate the two profiles is provided in the Geoarchaeology section of this report.

The artefacts are almost completely concentrated in a sandy layer just above an obvious cobble/pebble layer (Unit 3). An effort was made to remove the sediment from on top of this very artefact-rich layer without removing most of the artefacts, so as to obtain a broad lateral exposure of their sub-surface distribution as they lay on top of the lower sedimentary layer. The cobble surface, once exposed, was cleaned and photographed from several different angles before excavation resumed (Figure 18). There was a clear subsurface slope to the cobble layer from the northwest to the southeast part of the site, with a levelling off near the centre of the excavation area. Because the cobbles themselves may have been artefactual or otherwise modified in a way that could not be discerned in the field, a dot of black permanent marker was emplaced on the top of each one > 5 cm and they were also piece-plotted, which adds to the density plot showing the distribution of plotted finds at the site. Nonetheless, the majority of finds were flaked stone artefacts.
Figure 17 North and west profiles of the excavation at SS-I showing sample locations and stratigraphy (top). Below image is a georectified section photo of the north profile showing plotted finds locations (yellow dots).
Figure 18 Top: plan view of exposed cobble layer at SS-I with artefacts. Bottom: view north of the exposed cobble layer.
Any cobbles > 2 cm recovered from SS-I were also taken back to the field lab and processed to determine their raw material type and dimensions so that further analyses may reveal if mainly local raw materials were used in lithic reduction. The mean size of a sample of 1762 cobbles was 51.55 mm in maximum length, with a standard error of 0.49 mm – bearing in mind that the piece-plotted cobbles have yet to be measured, and those tended to be larger. 70% of the cobbles were quartzite, with the rest quartz. This is interesting given that several chert artefacts were recovered from the nearby 2012 geotrench. If the two profiles represent artefact depositions within similar timeframes, then it would suggest that chert cobbles had been sourced from somewhere off-site to produce artefacts.

Below the extremely dense artefact and then cobble layer at SS-I there are more artefacts, but fewer of them. The very low artefact abundances seen in the upper sands are then repeated below the cobble layer, with only approximately one find per subsequently excavated m³. The maximum depth to which any square was excavated was 2.4 m, and the contact between Chitimwe and Chiwondo Beds in three other test pits in the area suggests that continued excavation would also reveal the nature of this contact at SS-I.

The majority of sediments were clearly stratified, although an area of bioturbation was noted in the southeastern part of the site, distinguished by grey mottled sandy clay and occasional termite structures. Some had live termites in them. As discussed in the next section, there is not a clear relationship between the SS-I main excavation and the stratigraphy revealed in the 2012 geological trench. The most notable feature that is missing is a clear accumulation of iron and manganese nodules that occur in the geological trench in association with the handaxe. Such nodules also occur about 55 m to the southeast, at SS Test Pit 1. In this pit, several refitting artefacts show a clearly intact deposit, but its relationship to the stratigraphy at the SS-I main site will only be revealed through further analysis, dating, and possibly an extension trench between SS-I and the 2012 geological trench that also contained a clear iron nodule horizon.
Test Pits

The locations of the northwest corner of each of the SS Test Pits is provided in Table 4. Details of their individual sedimentology and characteristics of the lithic artefacts they contain are outlined in the Geoarchaeology and Lithic Analysis sections of this report.

**Table 4** Coordinates for the NW corners of each of the Sadala South Test Pits.

<table>
<thead>
<tr>
<th>Site</th>
<th>Area</th>
<th>Easting</th>
<th>Northing</th>
<th>Elevation</th>
</tr>
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<tbody>
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<td>SSTP</td>
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<td>599207.9013</td>
<td>8894168.553</td>
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<td>SSTP</td>
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<td>599116.786</td>
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<td>SSTP</td>
<td>3</td>
<td>599163.3456</td>
<td>8894247.677</td>
<td>553.04</td>
</tr>
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<td>SSTP</td>
<td>4</td>
<td>599329.8184</td>
<td>8894189.303</td>
<td>550.814</td>
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<td>SSTP</td>
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<td>552.773</td>
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<td>599284.047</td>
<td>8894559.194</td>
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<tr>
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<td>599460.0481</td>
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<td>8895100.635</td>
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<td>600311.3856</td>
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</tr>
</tbody>
</table>
**IV. SITE-SCALE GEOARCHAEOLOGY**

**Introduction**

Christopher Miller, Susan Mentzer and Flora Schilt from the Tübingen University in Germany joined MEMSAP in 2012 as geoarchaeological specialists. Christopher Miller is Junior Professor at the Institute for Archaeological Sciences (INA), Susan Mentzer is a post-doctoral researcher in Geoarchaeology, and Flora Schilt is a PhD student, supervised by Prof. Miller and Dr. Mentzer. They apply micromorphology and other micro-analytical techniques to study sediments and soils from the archaeological excavations in the Karonga district in order to reconstruct site formation histories and past human environments. Field work conducted in 2012 and 2013 has been reported in more detail in preceding MEMSAP field reports (Thompson et al. 2013a, Thompson et al. 2012b).

In 2014 Flora Schilt carried out field work from July 26th to August 17th. She collected 16 micromorphological samples with correlating loose sediment samples from all units and features included in the block samples, as well as 8 carbonate samples. Almost all of the micromorphological samples that were collected and transported to Tübingen in 2010, 2011 and 2012 have been processed into thin sections. All 2013 samples have been impregnated with resin and cut into blocks and part of them have been processed into thin sections. The other 2013 samples, together with about half of the 2014 block samples are ready to be thin sectioned. The other half of the 2014 samples are in the drying oven and will be impregnated soon (Table 6). Carbonate nodules have been cut in half and will be examined with cathodoluminescence microscopy before any other analysis can be performed. Regarding the use of a cathodoluminescence microscope we are in contact with the Geology Department of the University of Tübingen. All water samples collected to date are stored in a fridge at the Institute for Archaeological Sciences.

Micromorphological analyses of the excavation areas at Mwanganda’s Village and Chaminade II are nearly completed.
Table 5 All sites sampled, number of samples collected, number of samples processed into thin sections, number of thin sections, progress of the analyses and years in which samples were collected.

<table>
<thead>
<tr>
<th>Site</th>
<th>No. of samples</th>
<th>No. of samples finished processing</th>
<th>Year collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test pit near MGD I</td>
<td>3</td>
<td>3</td>
<td>2010</td>
</tr>
<tr>
<td>Cabonate nodule from MGD I</td>
<td>1</td>
<td>0</td>
<td>2014</td>
</tr>
<tr>
<td>MGD I extra loose samples</td>
<td>6</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>MGD II</td>
<td>4</td>
<td>4</td>
<td>2011</td>
</tr>
<tr>
<td>MGD III</td>
<td>6</td>
<td>6</td>
<td>2011, 2012</td>
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<tr>
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<td>3</td>
<td>0</td>
<td>2012, 2013</td>
</tr>
<tr>
<td>CHA I</td>
<td>3</td>
<td>2</td>
<td>2011, 2013</td>
</tr>
<tr>
<td>CHA II</td>
<td>7</td>
<td>7</td>
<td>2012</td>
</tr>
<tr>
<td>CHA III</td>
<td>5</td>
<td>4</td>
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</tr>
<tr>
<td>CHA IV</td>
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</tr>
<tr>
<td>Bruce septic tank</td>
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<td>1</td>
<td>2012</td>
</tr>
<tr>
<td>BRU I</td>
<td>4</td>
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<td>2013</td>
</tr>
<tr>
<td>BRU II</td>
<td>2</td>
<td>0</td>
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<td>BRU III CaCO₃ nodules</td>
<td>7</td>
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<td>2013</td>
</tr>
<tr>
<td>BRU-WELL</td>
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<td>2013</td>
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<td>2</td>
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<tr>
<td>Sadala South geotrench</td>
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<td>2012</td>
</tr>
<tr>
<td>APS (Airport Site)</td>
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<td>1</td>
<td>2010</td>
</tr>
<tr>
<td>KRW (Kafula Ridge West)</td>
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<td>1</td>
<td>2010</td>
</tr>
<tr>
<td>NRK (North Rukuru River Terrace)</td>
<td>1</td>
<td>0</td>
<td>2013</td>
</tr>
<tr>
<td>KCR (Karonga-Chitipa Road)</td>
<td>2</td>
<td>0</td>
<td>2013</td>
</tr>
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<td>MAL (Malema Chiwondo)</td>
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<td>2013</td>
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<td>Sadala South Site</td>
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<td>0</td>
<td>2014</td>
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<td>0</td>
<td>2014</td>
</tr>
<tr>
<td>Bruce Geotrench 2</td>
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<td>2014</td>
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<tr>
<td>CaCO₃ nodules from Bruce Geotrench 2</td>
<td>5</td>
<td>0</td>
<td>2014</td>
</tr>
</tbody>
</table>
Methods

Field Methods

Block samples for micromorphology were collected from exposed profiles in the field. The blocks were carved out 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 optically stimulated luminescence dating (OSL), in order to facilitate integration of the micromorphological results with those from the dating analyses.

Micromorphological samples were collected preferably at the contacts between stratigraphic units, so that they contain two types of sediment instead of one. The practical reason for this is that multiple types of sediment in one sample minimise the number of samples that need to be collected and processed as well as the number of petrographic thin sections that need to be produced. The scientific and more pertinent reason is that the morphology of the contact between two units can be informative about mode and energy of deposition, and the stability of former surfaces. Loose samples were taken from each geological unit included in the block samples. Before sample collection, all sedimentary and soil profiles were described and photographed.

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, crossed polarised light, blue light fluorescence, and oblique incident light (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 is an especially suitable method for archaeological contexts as it 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 the Karonga district are processed at the Institute for Archaeological Sciences in Tübingen, Germany. Block samples are oven-dried at ca. 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 some of the loose sediment samples as needed.

**Additional Analyses**

**Stable isotopic measurements (δ¹⁸O, δ¹³C)**

Oriented carbonate samples and loose samples of secondary carbonates have been collected from several archaeological and geological trenches located in different areas of the Karonga palaeolandscape: Mwanganda’s Village Areas I and III, Chaminade Test Pits 2 and 11, Bruce Area III, Geotrench 2 at Bruce and Test Pit 4 at Sadala South. 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 obtained using methods outlined...
in Mentzer and Quade (2013). With the methods described by Mentzer and Quade (2013), isotopic ratios can be directly linked with 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 recrystallisation that may have taken place.

**Uranium-series \( ^{234}\text{U} - ^{230}\text{Th} \) dating of secondary carbonates**

Loose samples of secondary carbonates will be directly dated using the \(^{234}\text{U} - ^{230}\text{Th} \) 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.

**Summary of 2014 Field Work**

In 2014, archaeological excavations were undertaken in Sadala and surroundings (Kasote village), ca. 6 km south of Karonga town. Apart from the main site of Sadala South, 17 test pits were excavated. They were positioned on the margins of a flat hill of Chitimwe sands and gravels, similar to the arrangement of the test pits and excavations in the Chaminade area. All profiles were documented (photographed and drawn) and described. Samples were collected at key locations and where certain features may aid in the general understanding of the Karonga sediments.

Test pits SSTP7 and SSTP16 were sampled for both micromorphology and OSL for a more detailed study of the sediments: their age, depositional history and post-depositional alterations.

In two test pits near the main site of Sadala South, SSTP4 and SSTP5, the Chitimwe alluvial fan deposits were underlain by Chiwondo sediments (Figure 19). They were sampled for micromorphology, so that the contact between the lacustrine and alluvial fan sediments
can be studied and their relation understood. Non-nodular carbonate samples were also collected from the lacustrine Chiwondo in SSTP4 for isotopic analysis and uranium series dating.

![Outcrop of the white Chiwondo Beds, just north of the main site of Sadala South (view south).](image)

**Figure 19** Outcrop of the white Chiwondo Beds, just north of the main site of Sadala South (view south).

**Sadala South**

**2012 Geotrench**

The main impetus for the archaeological excavations at Sadala South was the discovery of a handaxe in a geological trench that was excavated in 2012 under the supervision of Marina Bravo Foster and Scott Robinson (both PhD students at the time at Arizona State University under the supervision of Prof. J. Ramón Arrowsmith). From what is understood, the handaxe was lying on top of the fine to medium gravels of the mottled Unit 1 (5 % clay, 1-2 % 6-10 cm rounded semi-prismoidal cobbles, upper 10 cm horizontally oriented medium to coarse well-rounded pebbles), just inside the coarse to very coarse sands and very fine gravels of Unit 2 (5-10% clay). These sands also contained 0.5-1.5 cm black Fe/Mn nodules in a band of ca. 3 cm thickness following the inclination of the Units to the west (Figure 20). All units are poorly to very poorly sorted.
2014 SS-I Main Excavation

Correlation of the stratigraphy of the 2012 geotrench with the main excavation site of 2014 is not straightforward. The main excavation was placed at ca. 12.5 metres southwest of the geo-trench where the surface level was gently sloping down towards a modern gully. It contains two cobble layers that are inclined towards the north and west (ca. 15%). The lower one, Unit 2, consisted of coarse to very coarse pebbles and cobbles and was situated on top of Unit 1, which was composed of coarse sandy to very fine gravelly loam, coarsening upward to loamy fine to medium gravel, with clear redox masses (mottles). Unit 3 consisted of very fine to medium gravel with 10-20% subrounded to rounded coarse pebbles (clear redox masses), overlain by very coarse
pebbles and cobbles (Unit 4). On top of this upper cobble layer, artefacts were concentrated, as well as ca. 10 cm above in a separate artefact layer inside the slightly loamy sands and fine gravels of overlying Unit 6. Unit 5 is very fine to fine gravel that was observed in the southern part of the excavation only. The clear cobble layers observed in the main excavation were not observed in the geotrench but it is possible that they decline and fade further to the east and connect with the medium to coarse pebbles of the upper 10 cm of Unit 1 of the geotrench, overlying mottled clay-rich fine to medium gravels that are very similar to Unit 1 of the main site (Figure 21). There were no clear concentrations of manganese and iron nodules at the SS-I main site, although there were at Test Pit 1 only about 55 m southeast of the main excavation site.

Figure 21 West profile of Sadala South (square D4) with micromorphological samples MEM-6892 (SS-14-23) and MEM-6891 (SS-14-22), the latter wrapped in plaster-of-Paris. Dashed lines follow the course of the unit boundaries (unit 5 appears further to the south (D7, D8). b: Close up of the upper sample (MEM-6891) before it was wrapped in plaster-of-Paris showing an artefact (location framed in puzzle piece, also on figure a). c: Plane view on a clay impression observed underneath a cobble in the excavation.
Test Pit 3

Test Pit 3 was located just to the northwest from the main excavation. Here a clear cobble layer, similar to the upper cobble layer of the main excavation, makes an abrupt change in inclination (Figure 22), illustrating the dynamic nature of these deposits. All units at Sadala South main site were sampled for micromorphology (see sample list in Appendix 2).

Figure 22 Sadala South Test Pit 3, showing a sudden change in inclination of a cobble layer as indicated with the dashed lines in a.

Test Pits 4 and 5

Just east and north of Sadala South in test pits (Test Pit 4 and 5 respectively) and outcropping in the landscape, (Figure 19) Chiwondo Beds were observed. They are always very calcareous and usually soft and consist of well-sorted silt. However, Unit 1 in Test Pit 13 consisted of angular very coarse sand to very fine gravel-sized cemented quartz (Figure 23).
Figure 23 Sadala South Test Pit 13 with extremely hard white, sandy to very fine gravelly calcareous Chiwondo. Specimen appear brownish red after removal with a hammer and chisel.

In Test Pits 4 and 5 the Chiwondo lacustrine deposits were underlying red Chitimwe. In both cases bioturbation could be well observed because of the contrasting nature of the sediments and micromorphological samples were collected from the contact of the Chiwondo to the Chitimwe. In Test Pit 4 termite channels were observed and a sample inside the Chiwondo Beds here targets the long straight termite channels filled with red material inside the white calcareous Chiwondo. These channels are likely the result of termites burrowing down to reach the groundwater table (Lee 1971, Wielemaker 1984). Carbonate samples were also collected, so that different types and occurrences of carbonates on the area can be compared.
Figure 24 West Profile of Sadala South Test Pit 4 showing the contact between the white Chiwondo lake deposits (1: well sorted calcareous silt) and overlying dark red Chitimwe (2: loamy sand, 3: coarse to very coarse pebbles and cobbles, 4: sandy loam, 5: sandy clay loam). Channels, plastered and infilled with brown material deriving from above, extend downwards into the Chiwondo and illustrate termite activity. b: micromorphological sample MEM-6871 (SSTP4-14-02) captures units 1-3, including the contact between the Chiwondo and the Chitimwe. c: micromorphological sample MEM-6872 (SSTP4-14-03) was collected from inside the Chiwondo and aimed at capturing termite channels. d: One of the two carbonate block samples collected from this test pit (MEM-6878, SSTP4-14-09).
Test Pit 7 and Test Pit 16

Test Pit 7 was a 207 cm deep test pit, located at some distance from the main excavation to the north, next to a road. It had a clear and dense stratification with an abundance of artefacts as well as different kinds of redox features (Figure 26). For these reasons the test pit seemed especially suitable to help approach our goal to understand the relationships between human activity, the archaeological record, depositional processes, and post-depositional processes. Four micromorphological samples were collected as well as two samples for luminescence dating (see sample list in Appendix 2).
Test Pit 16 was located at closer proximity to the main site and ca. 115 cm deep. It contained a 30-40 cm thick layer of subrounded to well-rounded spherical to sub-prismoidal coarse to very coarse pebbles and cobbles (Unit 2) lying on top of medium gravels and pebbles (Unit 1). Unit 3 and 4 consisted of gravelly sand, fining upwards and increasingly bioturbated (Figure 27). Archaeological context 2 produced several refitting flakes and archaeological context 3 showed characteristics of centripetal technology (including a Levallois flake), making them more similar to the material from excavations at Chaminade than to the assemblage from the main site of Sadala South. The corresponding geological units 3 and 4 were therefore sampled for micromorphology, as well as for luminescence dating. Unit 2 was also sampled for micromorphology. This may seem peculiar because coarse pebbles and cobbles are very difficult to sample en bloc and the amount of informative materials captured in thin section may be limited. The purpose of this sample is to study the clays that are found in between the coarse grained material.
and compare these with clays observed elsewhere, for example in the deep sediments of CHA II or between coarse pebbles at MGD I. The observation of similarities and differences of the clays will aid in the reconstruction of their formation and depositional histories.

**SST 16 North Profile**

<table>
<thead>
<tr>
<th>Unit #</th>
<th>cm a.s.</th>
<th>C</th>
<th>Si</th>
<th>Sa</th>
<th>Gr</th>
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![Text]![Diagram]

**Figure 27** Sadala South Test Pit 16.

**Test Pit 9**

A sample from Test Pit 9, located on the opposite side (to the northeast) of the Sadala South study area, was collected from sediments with distinct redox masses (mottled zone) and small black Fe/Mn nodules (Figure 28). Similar to other instances, CHA II to name one, the nodules were associated with artefacts. It is hoped that the depositional and formational history of the nodules will shed light on the depositional history of the artefacts.
Geological trenches at Bruce

Three geological trenches were excavated below a washed-out area of the Bruce (CS-70) site to establish if that area was the site of a previous excavation in the 1960s by Desmond Clark and Van Eggars (Clark et al. 1970). Geotrench 1 measured 2 x 1 m, was oriented NE-SW, and located 40 m southeast of the MEMSAP Area I excavation. Geotrenches 2 and 3 were parallel with Geotrench 1, and measured 3 x 1 (47 m southeast) and 2 x 1 (51 m southeast), respectively. All had similar stratigraphy containing calcareous Chiwondo Bed material rich in macro plant remains overlain with two channel fill episodes. These were sampled for comparison to the carbonate nodules sampled in 2013 from MEMSAP Area III, which were likely of pedogenic origin (Figure 29).
A discussion of laterites, redox features, and Fe/Mn nodules is useful for clarifying their significance for our (geo)archaeological research in the Karonga area. Redoximorphic features, as defined by Vepraskas et al. (1993) are “features formed by the reduction, translocation, and oxidation of Fe and Mn compounds” (pg. 117). The three groups of redoximorphic features are redox concentrations, redox depletions and reduced matrices. They form under aquatic conditions as a result of alternating periods of oxidation and reduction. Saturation, reduction and redoximorphic features are criteria for the definition of aquatic conditions (Vepraskas et al. 1993). In tropical soils this is expected to happen lower down in the profile where an unstable, oscillating groundwater table causes changing conditions (Vepraskas et al. 1993). However, redoximorphic features such as redox masses (mottles) and Fe/Mn nodules can also form higher up in
the profile outside the reach of the groundwater as a product of pedogenic weathering (see below).

**Laterites** were first documented in India in a travel report by Buchanan (1807) who observed the material used for construction in the (Indian) regions he visited and described laterite as "*material which was initially soft enough to be cut into blocks by an iron instrument, but which became hard as brick on exposure to air*" (Buchanan 1807 p. 440 in McFarlane 1976). His description was more of a utilitarian sort and not meant to define a certain soil type. The physical properties he describes are the ones required for the production of brick, which is also reflected in the name “laterite”, from *later*, Latin for brick. There has been a lot of confusion and discussion about what a laterite is and how it should be defined (McFarlane 1976). In the end the term laterite was considered unsuitable for the designation of one single soil type but it is still in use in a more general sense and lateritisation is used here to describe the process of weathering under well-drained (non-saturated) conditions, leading to the depletion of silica (mainly quartz) and relative accumulation of both kaolinite and iron oxides (Fritsch *et al.* 2002). Fritsch *et al.* (2002 p. 4) used the following criteria to differentiate a latosol (a lateritic soil) from the underlying sediment:

- the upwards increase of clay content (from 40% up to 75%) and decreasing size of the quartz grains;
- the appearance of homogeneous soil horizons coloured by iron oxides and, close to the surface, by organic matter;
- the development of a medium to fine blocky structure and the appearance of numerous pseudo-sands (150 µm) that are diagnostic features for Latosols and linked to biological activity (mainly termites).

From the current state of the micromorphological analyses of the laterites in Karonga, these criteria are in accordance with observations in the area. The base of many lateritic profiles consists of a light coloured, clay-rich **pallid zone** underneath a zone with gleying and Fe masses which has also been described as a **mottled (clay) zone** (Tardy 1997, Schaetzl and Anderson 2005). Because the clays of the pallid zone are not necessarily
depleted in iron (pallid means pale, washed out) and because McFarlane (1976) had shown that they can impossibly serve as or have served as the source of the iron concentrations of the overlying sediments, which had been a common theory among previous scholars, Tardy (1997) proposed to use the term kaolinitic lithomarge instead. Other terms, such as fine saprolite, saprolite, plastic arene, etc. can also be found in the literature (Tardy 1997 p. 50). The mottled (clay) horizon develops at the expense of the lithomarge, which it progressively replaces downward (Tardy 1997, p. 59). Upwards the mottles (“mottles” has been replaced in Soil Taxonomy by “masses”, Vepraskas et al. 1993) increasingly coalesce until the entire profile surface is evenly oxidised and stained. Mottles and nodules form at clay-rich sites that function as “receptacles” for the accumulation of iron, either in pedogenic (secondary) kaolinitic clay accumulations (clay coatings) or in more clayey domains in the mottled horizon (Tardy 1997, p. 59).

Some scholars (McFarlane 1976, for example) make a distinction between groundwater laterites and pedogenic laterites. The processes that underlie their formation as well as some aspects of the resulting weathering products are different. In groundwater laterites precipitates develop within the zone of fluctuation of the groundwater table and their products are very similar to or the same as Vepraskas et al.’s (1993) redoximorphic features forming under aquic conditions. In pedogenic laterites alternating conditions of wetting and drying within the soil lead to removal of quartz and kaolinite and enrichment in Fe and/or Al. It is clear that the two different forms of lateritisation result from two different weathering processes, one acting from above and one from below. They oftentimes occur in the same profile but at different locations: pedogenetic laterisation near to the surface and groundwater laterisation (groundwater-related redoximorphic features) lower down in the profile where the (fluctuating) water table causes reducing conditions impacting the sediments (Schaetzl and Anderson 2005, Brimhall et al. 1991).

McFarlane (1976 p. 65) emphasised that ”the enormous scale of the typical profile argues strongly against the monogenetic development of the various horizons, and in particular against the synchronous and complementary development of the lower depleted horizons and the upper enriched horizons”. Tardy (1997, p. 11) concludes that all laterites have a
lower part that is primarily dominated by the nature of the bedrock and saturation and differs from place to place, while the upper portion of the profile is more sensitive to variations in the local climate and site conditions.

In this upper part, the lateritisation process leads to the enrichment in Fe or Al, compared with the kaolinised bedrock. McFarlane (1991b) proved the importance of microbial activity for the dissolution of quartz and kaolinite in laterites. Based on investigation of profiles in the Central Plains of Malawi, McFarlane and Bowden (McFarlane 1992) concluded that the observed extreme landsurface flattening is caused by "microbiially mediated kaolinite dissolution and saprolite collapse" (p. 803). McFarlane emphasises that quartz dissolution can be massive and that the resulting soft collapse and shrinkage of the lateritic residue is often understated (McFarlane 1991b, McFarlane 1991a, McFarlane 1992). This implies that the sediments have moved slightly with a mainly vertical movement and that they cannot be expected to be in situ. While Crossley (Crossley 1986) may have overvalued the active role of termites in the actual formation of laterites of the Chitimwe Formation at Sungwa and Chaminade ("the sand sheets have accumulated through vertical transfer of sediment by Macrotremes", (p. 191), and Goudie (1973) (p. 113) believed that termites played an important role in the lateritisation process by aerating the profile and promoting oxidisation, McFarlane (1976, p. 91) states that although a causal relationship between termites and laterite development is now largely discredited: "it is possible that termites can contribute to laterite genesis by facilitating the reworking of a soil in which precipitates develop, thereby aiding their concentration at the base of the soil, much as a stone line is developed". In Karonga, artefacts as well as Fe/Mn nodules are usually concentrated in horizontal zones. In the Karonga environment, post-depositional processes need to be taken into consideration as important agents in the accumulation of coarse material in discrete layers. Features related to lateritisation as well as groundwater-related redoximorphic features are observed in the archaeological profiles and only when the different aspects in play are understood can we start to understand the distribution of the archaeological finds (and accumulation of phytoliths and grains used for OSL dating).
One of the above mentioned forms of precipitates are **Fe/Mn nodules**, also referred to as pisoliths when they exhibit clear concentric zonation. They have been observed in several profiles in the study areas in the Karonga district (APS, CHA-I, CHA-II, CHTP9, SSTP7, SSTP9) and near the Bruce excavations where they are eroding from the surface. Because of their resilience, Fe/Mn nodules are resilient and may survive for a very long time but their history can be complicated and include several phases of formation, accumulation and redeposition. These can be reconstructed with micromorphology (combined with field observations) and provide valuable information about the depositional history of a site and the locations of artefact concentrations.

By which processes Fe/Mn nodules and pisoliths form has been unclear for a long time, probably because most observers intuitively interpret the concentrical zones of pisoliths as growth rings, assuming that they are formed by additions of material from the matrix (Taylor 2008, Eggleton 2006). However, Eggleton and Taylor (Eggleton 2006, Taylor 2008), who investigated bauxite and pisoliths in northern Australia as well as Delvigne (1999) and other authors (Nahon 1991, Jones 1965) found that the “growth-rings” in most pisoliths are actually formed by internal **centripetal reorganisation**, a process involving chemical and mineralogical changes in the nodule that start from the outer rim and go inward. This cortification is non-accretional and because of the internal re-organisation and smoothing of irregularities, the nodules become more spherical and smaller. Nahon (1991) brings the formation of pisoliths from nodules in relationship with wetting and drying in the soil and the reorganisation of clays in the surrounding matrix – Brewer’s **constraint cutans** (Brewer 1964). Delvigne suggests that water circulating through the matrix around the hard nodules causes pressure near the margins of the incompressible nodules leading to the orientation of clays. During the dry season a fissure develops around the nodule, separating the nodule from the surrounding matrix. This way the nodule is cut off from its Fe supply, and cortex formation is induced. The chemical changes within the nodules smooth out irregularities and make them rounder and more compact.

During subsequent development, **centrifugal cortification** may lead to the formation of accretion corteces (bands) around the nodules. Centrifugal cortification is also linked to
wetting and drying, which causes shrink and swell and the formation of fissures or contraction cracks around the nodules (Delvigne 1999, Nahon 1991). The circum-nodular fissures that are formed during the dry periods create pore space, allowing for the circulation of water and infilling with illuvial clay and/or precipitation of iron oxyhydroxides during the rainy period. The coatings rest against the outer cortex of the nodule where they become impregnated with iron oxyhydroxides. Afterwards they become indurated and contribute to the thickening of the cortex. The new outer band of the cortex may be composed of a different matrix than the inner part of the nodule, depending on whether the nodule has been moved from its original location. Therefore, the accretion corteces can be informative about the depositional history of a nodule.

Delvigne presents a wide range of nodules from Ivory Coast (Koua Bocca) in the *Atlas of Micromorphology of Mineral Alteration and Weathering* (Delvigne 1997). The nodules from the Karonga sites, when observed in thin sections, vary from site to site but similar types are explained in Delvigne's Atlas (Delvigne 1997). In Karonga, large sandy nodules without and with (irregular) banding are found as well as more spherical “pisoliths” with regular bands. Different iron phases can also be observed. Fe/Mn masses (mottles) are also very common in Karonga and the question arises under what conditions nodules form rather than masses. According to Vepraskas et al. (1993), the reason why nodules or concretions form as opposed to masses may be related to how fast air penetrates into a reduced horizon after saturation. When air penetrates slowly during draining, nodules and concretions may form, while in cases where air penetrates more quickly, masses will form (Blume and Schlichting 1985).

While Vepraskas et al., in “*Aquic conditions for Soil Taxonomy*” mention the formation of nodules under true aquic conditions, others consider the formation of Fe/Mn nodules under certain circumstances in laterites pedogenic and they have been treated as such in work on tropical soils and laterites (McFarlane 1976, Tardy 1997). McFarlane (1976, p. 23) states that in both immature groundwater and pedogenetic laterites nodules are spaced and found in situ, while in a slightly less immature state they become packed by residuum from above. Also, according to McFarlane nodules that have formed pedogenetically inside the soil increase in frequency towards the base, while
groundwater nodules form in the underlying saprolite or the mottled clay zone and increase in frequency upwards towards the base of the soil (Figure 30). The accumulation of nodules at the base of soils does not exactly reflect the position where they formed or where the profile is most suitable for precipitation. The distribution pattern is more strongly related to the natural migration of the heavy bodies towards the base and the processes of soil creep and bioturbation (McFarlane 1976, p. 73).

**Figure 30** Different distribution of pedogenetic and groundwater pisoliths according to McFarlane 1976, p. 74.

There are three general settings in which Fe/Mn nodules can be found. The first one is that they are at the location of their original formation, *in situ*. In this case they are loose, open spaced and most likely still forming. The second possibility is that they are *residual*, which means that they have considerably sunken down as a result of the continuous weathering and bioturbation that affect the laterites. The nodules are closely packed and surrounded by material of a different composition than their internal matrix, which is derived from their primary location of formation. The third general option is that the nodules are *detrital*, which means that they were deposited in a manner similar to the deposition of gravel. If the Fe/Mn nodule-gravels are buried after deposition they will likely further alter in their new surrounding matrix where conditions are different and may promote dissolution or the formation of new cortices (McFarlane 1976, Delvigne 1999).
V. OCHRE ANALYSIS

Ochre Source Sampling

During the 2014 MEMSAP field season, Andrew Zipkin continued identifying and sampling geologic sources of ochre pigments in northern Malawi. This work was begun in 2011, when Zipkin began identifying extant sources of ochre pigments on the landscape and collecting samples from these sources for geological and geochemical characterisation as part of broader archaeological pigment provenance project (Zipkin et al. 2015). His 2011 and 2012 fieldwork in Malawi resulted in the identification of multiple sources of ochre pigments, most of which were chemically distinguishable from one another on the basis of trace element composition. During analysis in 2015 he found that there was significant overlap between the ochre nodules sampled from river beds – especially the North Rukuru – and the Kayelekera sources, suggesting that ochre nodules were moving from their origin in the Karroo Supergroup to the lower part of the catchments. However, efforts to associate ochre pigment artefacts from the Middle Stone Age (MSA) site of Chaminade 1A, Karonga, Malawi with these sources were ineffective.

Zipkin and his geochemical collaborator Prof. John Hanchar (Memorial University of Newfoundland) believe that this is due to the sedimentary nature of the ochre source samples. Sedimentary ochre is derived from the weathering of iron-rich parent rocks and the subsequent transport and deposition of iron minerals like hematite and goethite in combination with dilutant minerals like quartz and various clay minerals. Sedimentary ochre deposits are subject to ongoing changes as a result of depositional and erosional processes at work on the northern Malawi landscape, and it is entirely possible that the sources sampled during the 2011 and 2012 seasons were not available during the MSA. Further source surveys were carried out in 2014 for the purpose of sampling ochre from deposits that would have been available when the ochre artefacts at Chaminade 1A, and other MSA sites under investigation by MEMSAP, were created. Zipkin completed a PhD dissertation in March 2015 that contains the results of his ochre analyses in Kenya, Zambia, and Malawi over the last four years.
The 2014 ochre survey identified ochre deposits in two geologic formations that would have been present during the MSA: the Sungwa Beds and the Dinosaur Beds, with ten samples collected in total (Figure 31).

![Map showing ochre samples](image)

**Figure 31** Ochre samples from Mwawembe area are from the Sungwa Beds. Samples from west of Nyungwe are from the Dinosaur Beds.

The Sungwa Beds are a single conglomeratic formation containing high quality quartzite cobbles and ochre in the form of red-brown and yellow-buff boulders of poorly sorted sandstone and mudstone. The ochre samples collected from this formation in 2014 were eroding out of a cliff face exposure located west of the Mkungwe River in an area known locally as Mwawembe. The fact that the ochre is represented in the Sungwa Beds in the form of large, moderately to well-rounded clasts indicates that this is at least a secondary depositional location for the ochre which was presumably eroded from older deposits and was transported when the Sungwa Beds were being deposited in Tertiary times (Stephens 1966). It is possible that the ochreous boulders are originally derived from the fossiliferous Dinosaur Beds which underlie the Sungwa formation and of which the
Sungwa Formation may in fact be a part. Previous field work by Zipkin identified ochreous boulders and clasts (Figure 32) in the bed of the Wayi River that qualitatively are very similar to the ochre collected from the Sungwa Beds.

![Ochreous boulder in the bed of the Wayi River.](image)

The Sungwa Beds may have been an important source of raw material for the MSA inhabitants of northern Malawi; landscape survey by Thompson et al. (2014a) suggested that quartzite cobbles for stone tool production may have been provisioned from Sungwa Bed deposits in the North Rukuru River catchment.

**Figure 32** Ochreous boulder in the bed of the Wayi River.

Finally, during the 2014 season efforts were made to locate and collect samples of iron ore from the Nyungwe area. A proposed mine is located somewhere in this region according to local news reports from 2013 (http://www.nyasatimes.com/2013/08/08/kyungu-halts-mining-activities-of-new-china-company-we-are-not-fools/). The ore in this area was identified as limonite, a mixture of iron oxides and oxyhydroxides that can take the form of yellow ochre. Interviews with local residents and correspondence with George Maneya, the regional mining engineer for Northern Malawi, led to Kamtembo’s Village, part of the area of study west of Nyungwe, where the local chief GVH Kamtembo showed an example of high quality ilmenite-magnetite ore collected by his son-in-law. Ultimately however, the ore body was not located during survey and no samples were collected directly from the source. Further research in this region may be useful during the next field season before mining activity destroys the ore body.
VI. 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 2014 included: 1) analysis and refitting of artefacts from all 17 Test Pits at Sadala South (SSTP); 3) Completion of analysis of artefacts from all 21 Chaminade Test Pits excavated in 2012 (CS); 3) Refitting of artefacts from CHA-II; 4) Initial organisation and analysis of artefacts from CHA-III to prepare it for full study in 2015; 5) Collection of artefacts from the same surface of the Bruce (CS-70) site to quantify the amount of movement and exposure since a similar surface collection in 2012; and 6) Collection of cobble attribute data from Sadala South I (SS-I).

In total during the 2014 fieldwork, more than 5,500 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). Mackay provided preliminary observations of new plotted and sieve-recovered finds 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 further north or the south, it is equally likely that the MSA stone tools of Karonga will reveal local traditions that have developed \textit{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.

\textbf{Summary of activities}

In the 2014 field season, artefacts recovered from the 2012 and 2014 test pitting programs at Chaminade and Sadala, respectively, were analysed according to quantitative and qualitative characteristics in a typo-technological classification system. From the Chaminade Survey of 2012, 2121 artefacts from Test Pits 1, 2, 14, 15, 16, and 17 were analyzed during the 2014 field season; 3420 artefacts from the test pits of the 2014 Sadala Survey (Test Pits 1-17) were analyzed as well.

Chaminade I was examined for a final time, to identify any final refitting artefacts. A few artefacts from Chaminade II were also analyzed, as they had been mistakenly packed with material from other excavations. The plotted finds from Bruce Area I (excavated in 2012 and 2013) had been analyzed in 2013, but time constraints did not permit analysis of the sieved finds from that area; this was completed in the 2014 field season. Additionally, a few of the upper contexts from the Sadala South excavation were analyzed, but in such low numbers that a summary of the resulting data is of negligible utility.

\textbf{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 \textit{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**

A comparative overview of the general trends observed between the test pits excavated in the Chaminade area and the Sadala South area is given in Figure 33.

![Figure 33 Overview of general trends in lithic technology and assemblage composition between the two main alluvial fan remnants that have been comprehensively test-pitted.](image-url)
Sadala South Test Pits

SSTP 1

<<Unit 3 (fine gravel) is the main artefact concentration in TP 1, and shows a preferential and exhaustive use of quartzite cobbles (in contrast to the units above), and in situ deposition of artefacts.>>

The main concentration of artefacts in TP 1 was in Unit 3, around the middle depth of the pit, though artefacts appeared in both Unit 5 and Unit 4 above (Figure 34); no artefacts were recovered from the lowest depositional units. A total of 40 artefacts were found in Unit 5 (Contexts 1 and 2), 60% quartz (n = 24) and 40% quartzite (n = 16). Among the quartz artefacts in Unit 5, six cores were found, of an average size of 107.5mm, and predominantly single platform in reduction method, though several could almost be classed as radial cores (being worked on a single face around most of a single perimeter/platform). Of the three quartzite cores recovered, one was a multiplatform core, one a radial or likely Levallois core, and the other indeterminate; average size for these cores is 88mm. The rest of the artefacts from this unit were a few complete flakes, but mostly flake fragments and angular shatter. The finds were minimally weathered.

Unit 4 (Context 3) had 47 artefacts, 33 quartz (70.2%), 13 quartzite (27.6%), and one chert/fine-grained siliceous rock (2%). The artefacts from this unit are unweathered. One radial quartz core was found, ten quartz flakes or flake fragments, and 22 pieces of quartz angular shatter. A single platform quartzite core was found, as well as five flakes or flake fragments, and seven pieces of angular shatter. The quartzite flake fragments are

![Figure 34 Raw material abundances in SS TP 1 artefacts.](chart_image)
generally larger than those of quartz (avg. size = 60mm vs 33mm, respectively), suggesting larger original sizes for flakes at this locality.

Unit 3 (Contexts 5 and 9) was the main artefact concentration, with a total of 173 artefacts: 40 quartz (23.1%), 132 quartzite (76.3%), and one chert (0.5%). These frequencies are in stark contrast to the Units above, where quartz dominated. Most finds were associated with iron and manganese nodule formation. In Unit 3, the quartz artefacts were mostly angular shatter and flake fragments, with only three complete flakes (avg. size 36 cm). The quartzite artefacts included three complete cores in size classes 5, 13, and 15, two flaked using single platform reduction and a nearly-radial core that was found to have refitting and many non-refitting flakes of the same material in the same unit; a total of 50 artefacts were identified to have come from this single toolstone nodule, which initially must have been much larger than the exhausted core (Figure 35). Eighty-six flakes or flake fragments were found, and 43 pieces of angular shatter; many of these two classes of quartzite artefacts are from two distinct raw material groups, and though refits are lacking for most, clearly show the reduction of two larger cores on this site. The smaller fraction that would be expected with in situ lithic reduction was not recovered, either due to collection practices or because of winnowing following deposition but prior to excavation; the first scenario is favored due to the large number of artefacts that are clearly from one or two cores.

**SSTP 2**

<<Unit 2 (poorly sorted coarse sand) contains the main artefact concentration, which is largely composed of quartz artefacts, and is characterised by platform core reduction. Refitting artefacts in this unit indicate largely intact deposition.>>
In the uppermost Unit 3 (Context 1), only ten artefacts were recovered—five each of quartz and quartzite (Figure 36). Among these were a single platform quartzite core, size class 11, one complete quartzite flake, and a mixture of quartz and quartzite flake fragments and angular shatter. Artefacts in this Unit are only minimally weathered or rounded.

Unit 2 (Contexts 2 – 4) contained the greatest number of artefacts in this pit, with a total of 321: 184 quartz (57.3%), 133 quartzite (41.4%), three possible ferricrete artefacts (0.9%), and one chert/fine-grained siliceous piece of angular shatter (0.3%). Among the quartz artefacts were five cores (four complete)—three radially flaked and two single platform/casual (five flake scars or less) cores, with moderate cortex coverage and between sizes class 5 and 8. Seventy-four flakes and flake fragments were found; of these, seven were complete flakes, with an average size class of 3, though all fragments together have an average size of 34mm, meaning that the complete flakes are among the smaller in the range present in this unit. The majority of flakes and flake fragments show unidirectional flaking and have plain platforms, which may indicate single platform core reduction. One hundred and two pieces of quartz angular shatter were found, at an average size of 28mm. In the quartzite portion of the assemblage, four cores were identified—of single-, double-, or multiplatform reduction—and ranging from size class 6 to 10. Of the 85 quartzite flakes and flake fragments, 14 were complete, with an average size class of 5, predominantly with plain platforms and centripetal or unidirectional flaking. Forty-three pieces of quartzite angular shatter were also recovered. The three ferricrete (?) artefacts include one complete flake, a flake fragment, and a piece of angular shatter, all of which are clearly from the same worked nodule of tool stone; both of the flakes have plain platforms and

**Figure 36** Raw materials by context in SS TP 2.
are unidirectionally flaked, and the piece of angular shatter refits to the complete flake. These artefacts may have come from a platform core, or may represent relatively early stages of reduction, given the modest cortex that remains on each of them.

Unit 1 (Contexts 5 – 9) was comprised of 138 artefacts: 100 quartz (72.4%), 34 quartzite (24.6%), three ferricrete(?) (2.1%), and one chert/fine-grained siliceous piece of shatter (0.7%). The three possible ferricrete pieces do not refit, but are seem very likely to be from the same nodule as those in Unit 2; it is possible that these artefacts have been slightly displaced either through post-depositional movement or through the excavation process. The relative abundance of quartz in this unit is a large change from Unit 2 above, and includes one casual core (size class 6), 30 flakes and flake fragments—most with cortical platforms and unidirectional flaking—and 69 pieces of angular shatter. Two single platform quartzite cores were found in this unit (size classes 6 and 8), along with 20 flakes and flake fragments—again, mostly with cortical platforms and unidirectional flaking—and 11 pieces of angular shatter. For the entire unit, weathering is minimal, and quartzite artefact are only slightly larger on average than those on quartz.

**SSTP 3**

<<Unit 4 (poorly sorted gravel) contains the main artefact concentration in TP 3, though artefact numbers are minimal throughout. Quartz and quartzite artefacts are fairly equally represented (Figure 37), and platform cores are slightly more common than other types. A hammerstone/grindstone artefact is unique in this unit.>>

![SS TP 3 artefacts](image)

*Figure 37* Raw materials by context in SS TP 3.

Of the five depositional units found in TP 3, only the three topmost yielded artefacts. Unit 5 (Context 1) produced a total of 16: 13 quartz (81.3%) and three quartzite (18.7%).
quartz artefacts included one flake fragment and 12 pieces of angular shatter. The quartzite artefacts included one complete flake (plain platform, unidirectional flaking), one flake fragment, and one piece of shatter.

Unit 4 (Context 2) produced 52 artefacts: 27 quartz (51.9%) and 25 quartzite (48.1%). Two quartz cores were found—one a multiplatform core (SC 9) and the other a unifacially radially flaked core (SC 12)—and one tested cobble or casual core. Thirteen flake fragments and ten pieces of angular shatter were also recovered from the quartz fraction, as well as a complete hammerstone-grindstone artefact (SC 7; Figure 38) with clear pecking on one surface that intrudes on what appears to be an earlier ground surface. A single platform quartzite core and a tested quartzite cobble were also found in Unit 4, in addition to 11 flakes and flake fragments and 12 pieces of angular shatter.

Unit 3 (Context 3) was the lowest artefact producing unit, with a total of 12 artefacts: 4 quartz (33.3%), 7 quartzite (58.3%), and one mudstone flake fragment (8.3%). The flakes and flake fragments of all materials have predominantly cortical or plain platforms, and feature unidirectional flaking.

**SSTP 4**
<<The two uppermost units of TP 4 (Unit 5, sandy clay loam; Unit 4, sandy loam) contain the only artefacts in the pit, but are present in minimal numbers. Ceramic fragments were present in both units, although the lithic artefacts have classic MSA characteristics, suggesting that artefact deposition in this test pit is significantly reworked.>>
Artefacts were found in the top two depositional units of TP 4, though numbers of artefacts were low in each unit, and include recent ceramic fragments (Figure 39). Unit 5 (Context 1) yielded 24 artefacts total: 15 ceramic/pottery fragments (62.5%, including a rim and an incised piece), four quartz pieces (16.7%: three flake fragments, and one piece of angular shatter), and five quartzite artefacts (20.8%: four flake fragments, and one piece of angular shatter).

Unit 4 (Contexts 2 and 3) had a total of 37 artefacts: 10 ceramic fragments (27%, some with red glaze), 13 quartz artefacts (35.1%), and 14 quartzite artefacts (37.8%). Among the quartz artefacts were two complete multiplatform cores (SC 8, 10), one complete flake (SC 7, perhaps a Kombewa removal), and four flake fragments, and six pieces of angular shatter. Quartz flake platforms are diverse: cortical, plain, dihedral, and faceted, though most flaking is unidirectional. Two quartzite cores were recovered (SC 8, 11), both radially flaked; ten flake fragments were also found, with predominantly cortical and dihedral platforms and unidirectional or bidirectional flaking. Two pieces of quartzite angular shatter were also recovered. In general, the quartzite flake fragments are larger than those on quartz (avg. SC 4.6 vs 3.8), and the variance in reduction styles between the quartz and quartzite cores and flakes may reflect a relationship between reduction method and toolstone nodule size (as quartz cobbles tend to be smaller than quartzite cobbles); however, small sample sizes in this unit may be conflating patterns, and it is also worth noting that there is minimal, but present, weathering in all portions of the same—one of the quartzite cores has even begun to recorticate—indicating that this assemblage may be secondarily reworked. This is in agreement with the presence of ceramic in the same unit.
SSTP 5

<<In TP 5, artefacts appear in the upper three depositional units, though in low numbers. The frequency of quartz is highest in Unit 5 (topsoil) and decreases though Unit 4 (fine gravel) and Unit 3 (pebbles and cobbles). Lithic reduction is predominantly of platform cores.>>

Test Pit 5 yielded artefacts from the top three depositional units (3, 4, and 5), but none from Units 1 and 2. In Unit 5 (Context 1), 28 artefacts were found: 23 quartz (82.1%) and 5 quartzite (17.9%). Among the seven quartz flake fragments, four had plain platforms and one a cortical platform, and flaking was predominantly unidirectional; sixteen quartz pieces of angular shatter were also found. Of the five quartzite artefacts, two were flake fragments, and three were pieces of angular shatter (Figure 40). Quartzite flake fragments and angular shatter were, on average, slightly larger than quartz artefacts of the same types. Weathering on all artefacts from Unit 5 is minimal, though present on approximately 20% of the sample.

Unit 4 (Contexts 2, 4, 6, and 8) had a total of 54 artefacts: 36 quartz (66.7%), 17 quartzite (31.5%), and one ferricrete (1.8%). The single ferricrete flake fragment appears to have been recycled—some flake scars are very weathered, and those surfaces have begun to recorticate, while others are relatively fresh. One quartz core (SC 9), possibly radially flaked, was found, as well 11 flake fragments and 24 pieces of angular shatter. Flake platforms are mostly plain and cortical, and the majority of flaking is either unidirectional or indeterminate. One quartzite core (SC 12) was recovered, a bifacially worked single platform core; additionally, three complete flakes, 11 flake fragments, and two pieces of quartzite shatter were found. As with the quartz fraction, the quartzite flakes mostly have
cortical and plain platforms, and are unidirectionally or centripetally flaked, suggesting single platform or radial core reduction.

Unit 3 (Contexts 3, 5, 7, and 9) contained a total of 36 artefacts: 16 quartz (44.4%) and 20 quartzite (55.6%). Among the quartz artefacts are two single platform cores (both SC 10), 10 flakes or flake fragments with predominantly cortical platforms and unidirectional flaking, and four pieces of angular shatter. The quartzite fraction includes two cores—a single platform core (SC 6) and a multiplatform core (SC 10) on the coarse-grained Xq quartzite shown on the geological maps, nine flake fragments with plain and cortical platforms and unidirectional flaking, and nine pieces of angular shatter. The combined information from Unit 3 suggests a predominance of platform core reduction, rather than radial reduction, with larger quartzite artefacts being the likely result of larger toolstone packages. Approximately 30-50% of artefacts in all units are mildly weathered.

**SSTP 6**

<<Unit 3 (very fine to coarse gravel) contains the main artefact concentration in TP 6, with roughly equal representation of quartz and quartzite objects, and two groups of artefacts from two distinct Xq quartzite cobbles. Cores are few, but show both radial and platform reduction. In Unit 4 above (topsoil), most artefacts are quartz, and in Unit 2 below (poorly sorted pebbles) most are quartzite and show more radial reduction (and significantly more weathering).>>

Three of the four depositional units in TP 6 contained lithic artefacts, the densest concentration being Unit 3. In uppermost Unit 4 (Contexts 1, 2, and 3) of the pit, 26 artefacts were found (Figure 41). Twenty-five of these were quartz (96.2%), and only one was quartzite (3.8%; a complete flake from early in the reduction

![SS TP 6 artefacts](image)

**Figure 41** Raw materials by context in SSTP 6.
sequence). Among the quartz artefacts, ten are flake fragments, and fifteen are pieces of angular shatter. The flake fragments have a variety of characteristics, with no single reduction style dominating the group.

Unit 3 (Contexts 3, 4, and 6) contained 140 artefacts: 67 quartz (47.9%), 71 quartzite (50.7%), one ferricrete (0.7%), and one on fossil wood (0.7%). The quartz artefacts include a single radial core (SC 8), a tested cobbles (SC 7), 2 complete and 26 fragmentary flakes, and 37 pieces of angular shatter. Flake platforms are plain, cortical, and dihedral, and flaking patterns are typically unidirectional and bidirectional orthogonal; these characteristics may suggest platform or radial core reduction. Among the pieces of angular shatter are four non-refitting pieces that clearly come from the same toolstone package. Two quartzite cores were recovered—one radial (SC 6) and one that could be classed as a bifacial single platform core, or some type of “chopper tool,” with a row of small removals along a restriction portion of the hemispherical perimeter of the core, creating a continuous sharp edge. Four complete and 30 fragmentary quartzite flakes were also found; the flakes typically have plain or cortical platforms, and feature unidirectional, bidirectional orthogonal, and occasionally centripetal reduction. On average, quartzite flakes and flake fragments are larger than quartz flakes and fragments (complete flake avg. SC 4.75 vs. 3.5; flake fragment avg. SC 4.4 vs. 3.5). Within the quartzite fraction of the assemblage, two groups of artefacts were identified that clearly come from two Xq quartzite cobbles, though only a few pieces of each refit. It is likely that reduction of these cobbles occurred very near to the point of deposition. That only some artefacts within this unit are minimally weathered also suggests that major secondary reworking did not occur with these artefacts.

Only 25 artefacts were recovered from Unit 2 (Contexts 5, 7, 8, and 9): 6 quartz (24%), 18 quartzite (72%), and one flake on fossil wood (4%). The quartz artefacts include one multiplatform core, three flake fragments with cortical platforms (avg. SC 5.6), and two pieces of angular shatter; only two of the quartz artefacts show minimal weathering, while the rest are fresh. In contrast, the quartzite fraction of Unit 2 is significantly weathered, with only two artefacts showing no signs of abrasion or rounding, and the rest rating in weathering classes 2 and 3. Among these artefacts are one tested or broken
cobble and seven complete cores—five radial or roughly radial cores, and two platform cores (avg. SC 8.29). Seven complete and fragmentary quartzite flakes were found (avg. SC 6.43), most with cortical platforms, along with three pieces of angular shatter.

SSTP 7

<<Unit 3 contains the greatest artefact concentration in the pit, and within this unit, quartz artefacts become larger and more numerous with increasing depth. A number of artefacts from at least four distinct raw material groups were found, suggesting little reworking of this deposit in the upper portion.>>

Of the five deposition units excavated in TP 7, only the three middle units yielded lithic artefacts (Figure 42). Unit 4 (Contexts 2 and 3) produced 78 artefacts: 44 quartz (56.4%) and 34 quartzite (43.6%). Three complete (SC 3) and 18 fragmentary quartz flakes were predominantly produced on very large-grained/crystalline quartz, with mostly cortical platforms, but also some plain and dihedral platforms represented. A further 23 pieces of quartz angular shatter were recovered, four of which refit into two groups. The other flakes, fragments, and shatter may also be from one or a few quartz cobbles, though more refits were not found. The quartzite artefacts include a single platform core (SC 12), four complete (SC 4.5) and ten fragmentary flakes, most with cortical or plain platforms and unidirectional flaking, and 19 pieces of angular shatter, 17 of which are non-refitting.
pieces of the same Xq quartzite nodule. With the exception of three minimally weathered (WC 1) pieces, all of the artefacts from Unit 4 are fresh.

Unit 3 (Contexts 4, 5, and 6) contains a total of 537 artefacts: 108 in Context 4, 297 in Context 5, and 132 in Context 6. Within Context 4, 48 (44.4%) of the 108 artefacts are quartz and 60 (55.6%) are quartzite. The quartz finds include one casual core (SC 8), 15 flake fragments (avg. SC 3.9), and 32 pieces of angular shatter (avg. SC 3.3). The quartzite finds include two radial cores (SC 7), one complete flake (SC 12) and 24 flake fragments (avg. SC 4.7), and 33 pieces of shatter (avg. SC 3.27). Flakes and flake fragments from Context 4 have cortical and plain platforms and are unidirectionally flaked.

In Context 5 (Unit 3), 151 (50.8%) of the artefacts are quartz, 143 (48.1%) are quartzite, and three are chert or fossil wood (1%). Among both quartz and quartzite flakes and flake fragments, the majority have cortical or plain platforms, though a significant number have dihedral platforms; unidirectional and bidirectional orthogonal flaking are most common, followed by centripetal flaking.

Size differences exist between quartz and quartzite artefacts: complete quartz flakes (n = 4) have an average size class of 4.3, while complete quartzite flakes (n = 13) have an average size class of 5.8; this pattern holds for fragmentary flakes (avg. SC 3.2 vs 4.2). Context 5 also produced a quartzite core-on-flake, which refits with two flake fragments, and three other groups of refitting and non-refitting pieces (one group of platform core removals pictured in Figure 43), strongly suggesting that this context in largely in situ, further supported by minimal weathering on only a small portion of the artefacts. A high degree of cortical flakes also suggests that primary reduction took place in this location.
In Context 6 (Unit 3), 79 artefacts (59.3%) are quartz, 51 (38.6%) are quartzite, and one each of chert and mudstone (1.5% total). The quartz artefacts include 25 complete and fragmentary flakes and 54 pieces of shatter; quartzite artefacts include 21 complete and fragmentary flakes and 30 pieces of angular shatter. In contrast to Context 5 above, the quartz artefacts in Context 6 are larger on average than the quartzite artefacts: complete quartz flakes have an average size class of 4.5, while complete quartzite flakes have an average size class of 4 (fragmentary flakes = avg. SC 3.4 vs. 3).

Throughout Unit 3, therefore, there exist differences in raw material frequencies and artefact size—quartz artefacts become more common and larger deeper in the unit, while quartzite artefacts become less common and smaller deeper in the unit. It is also noteworthy that artefacts deeper in the unit are more often weathered compared to those at the top of the unit—it may be that the lower contexts of Unit 3 have been reworked, with the expected smaller portions winnowed away and leaving an over-representation of larger pieces.

Unit 2 (Contexts 7, 8, and 9) produced a total of 154 artefacts: 52 quartz (33.8%), 97 quartzite (59.1%), one mudstone (0.6%), and four pieces of chert (2.6%; two flaked pieces and two unworked nodules). In the quartz fraction is one radial or bifacial single platform core and two possible cores or battered/broken cobbles, four complete flakes (avg. SC 4.25) and 19 flake fragments (avg. SC 3.7) with mostly cortical and plain platforms and unidirectional flaking, and 26 pieces of angular shatter. This unit also yielded 5 quartzite cores (SC 6-8): three radial, one casual, and one core-on-flake. Eleven complete flakes were found (avg. SC 4.5) and 54 flake fragments (avg. SC 4.2), most with cortical or plain platforms and unidirectional or bidirectional orthogonal flaking, and 27 pieces of angular shatter. Most artefacts from Unit 2 are moderately weathered.
SSTP 8

<<The majority of artefacts in TP 8 were found in Unit 4 (very fine gravel with no bedding) and Unit 3 (fine gravel coarsening upward to stringer). Quartzite artefacts become more common with increased depth in the pit. Throughout the test pit, artefacts are often radially reduced, and include a significant Levallois component (with possible Levallois core-on-flake reduction).>>

The uppermost Unit 6 (Context 1) of TP 8 only contains three artefacts: a ceramic fragment and a flake fragment each of quartz and quartzite (Figure 44). Unit 5 (Contexts 2 and 4) contains five artefacts: three pieces of quartz shatter and two quartzite flake fragments. Units 4 and 3 were in places excavated together, and so analysis here will combine the two when it is otherwise impossible to differentiate the two. Only six artefacts were found firmly in Unit 4: a quartz radial core, a quartz flake fragment, a piece of quartz angular shatter, a quartzite multiplatform core and tested cobble, and a ferricrete flake fragment.

In those contexts that include both Unit 4 and 3 (Contexts 3, 7, and 9), a total of 62 artefacts were found: 34 quartz (54.8%) and 28 quartzite (45.2%). Quartz artefacts include 16 complete and fragmentary flakes (avg. SC 6.5 and 4.6) and 18 pieces of angular shatter (avg. SC 3.2). Quartzite artefacts include 21 complete and fragmentary flakes (avg. SC 6.7 and 5), four pieces of shatter (avg. SC 2.5), and three cores (one casual, one minimially radial, and one Levallois core). Almost 75% of artefacts in this group have minimal or moderate weathering, which may suggest that this is not an intact deposit.
However, at least two groups of refitting artefacts (six and two pieces each) were found within these contexts, which may indicate that any reworking of the unit was minimal.

Thirty artefacts were found exclusively in Unit 3 (Contexts 5, 10, and 11): 10 quartz (33.3%) and 20 quartzite (66.7%). Among the quartz artefacts are one tested cobble, five complete or fragmentary flakes, and four pieces of angular shatter. Quartzite artefacts include a recycled casual core, a beautiful fresh Levallois core with refitting preferential flake (Figure 45), eight other complete and fragmentary flakes, and eight pieces of angular shatter.

All of the finds from the lower units of TP8 come from Context 12, which spans both Unit 1 and 2. Fifteen artefacts were recovered from this context: three quartz flake fragments, four quartzite cores (one bifacial single platform, one roughly radial casual core, and two possible Levallois cores-on-flakes), five sizable complete flakes (avg. SC 7.2) and one fragmentary flake, and two pieces of angular shatter. Quartzite objects are larger on average than quartz objects in this context, however it is likely that this is a biased sample, as all artefacts in Context 12 show signs of weathering, with an average weathering class of 2.5.

**SSTP 9**

<<Most of the artefacts in TP 9 were found in the base of Unit 2 (fine gravel and coarse sand), which is likely not significantly reworked based on refitting artefacts. Most artefacts are quartz, and reduction patterns on flakes could represent a variety of flaking strategies.>>
TP 9 contains three depositional units, the middle and largest of which contains the majority of the lithic artefacts found in the pit. Unit 3 (Context 1), closest to the surface, yielded a single artefact: a quartzite flake fragment.

Unit 2 is comprised of Contexts 2-13, though most of the artefacts are at the base of the unit, in Contexts 12 and 13 (Figure 46). In the upper portion, Contexts 2-6, four artefacts were found: one quartzite flake fragment, a quartz flake fragment, a piece of quartz shatter, and a very large quartz grindstone (SC 18) with a single, concave grinding surface. Contexts 12 and 13 produced a total of 114 artefacts: 80 quartz (70.2%) and 34 quartzite (29.8%). The quartz artefacts include 20 flake fragments (avg. size class 3.1; plain and cortical platforms, mostly unidirectional flaking) and 60 pieces of angular shatter (avg. size class 2.35). Quartzite artefacts include four complete flakes (avg. size class 6.5), 12 flake fragments (avg. size class 5), and 18 pieces of angular shatter (avg. size class 2.7). Two groups of quartzite artefacts were identified that come from two distinct toolstone packages, and while a number of the artefacts from this Unit show minimal weathering, it seems that secondary deposition was not a major factor in the development of this assemblage. Context 12 produced 90 artefacts at an excavation extent of 1 x 2 m, whereas Context 13 produced 24 at a 1 x 1 m extent; it appears that Context 12 then represents the main deposition of artefacts in the unit, and the paucity of artefacts above it may be due to truncation of artefact-bearing sediments or a hiatus in tool production in the general area.

Unit 1 (Context 14) only produced one quartz flake fragment (and a possible quartz core that may only be a battered stone).

![Figure 46 Raw materials by context in SS TP 9.](image-url)
SSTP 10

<<Most artefacts in TP 10 are quartz, and though minimal weathering suggests that secondary reworking may not have significantly affected the artefacts, the low numbers of artefacts indicates that this was not an area of significant lithic reduction.>>

TP 10 contained only one depositional unit, and lithic artefacts were rare throughout. Thirty-one artefacts were recovered between Contexts 4 and 11, including 11 quartz flake fragments, 18 pieces of quartz angular shatter, one quartzite flake fragment, and one piece of quartzite angular shatter (Figure 47). Of all the artefacts, only two show any signs of weathering (WC 1), while the rest appear fresh. This suggests that artefacts were probably not significantly transported following deposition, though the diffuse nature of the artefacts in the pit supports the idea that this was not a knapping- or major activity location either.

SSTP 11

<<Artefacts from TP 11 are concentrated in Contexts 4 and 5 of Unit 1 (poorly sorted very coarse sand). The low artefact numbers, predominance of quartz, and minimal weathering are similar to the patterns seen in TP 10.>>
Twenty-one artefacts were found in TP 11, all from Unit 1 (Contexts 3 – 12). Twenty of the finds were from Contexts 4 and 5, and include two complete quartz flakes (avg. SC 4) and six fragmentary quartz flakes, nine pieces of quartz angular shatter, one complete single platform quartzite core (SC 10), one quartzite flake fragment, and one piece of quartzite angular shatter (Figure 48). The sole artefact from Context 11 is an extensively worked quartz multiplatform core (SC 12). Only three of the artefacts from TP 11 show signs of weathering (WC 1). The small number of finds from this test pit perhaps indicate a similar lithic working/landscape use history as TP 10.

SSTP 12

<<The majority of artefacts are found in Unit 6 (coarse sand), Unit 5 (poorly sorted sandy gravel), and Unit 4 (medium gravel with pebble stringer). Throughout these three units, quartz artefacts increase in number with increasing depth. Cores are often radially flaked within these three units, though no single reduction pattern dominates in these layers.>>

TP 12 produced a total of 222 lithic artefacts throughout its eight depositional units (Figure 49). At the top of the pit, a single quartz flake fragment was found in Context 1 (Unit 7/8). Unit 6 (Context 2) yielded 51 artefacts: 23 quartz (45.1%), 27 quartzite (52.9%), and one chert or mudstone flake fragment (2%). The quartz artefacts include eight complete and fragmentary flakes and 15 pieces of angular shatter.

The quartzite artefacts include a tested cobble, 16 complete and fragmentary flakes, and 10 pieces of angular shatter. Among the flakes, reduction patterns are varied, with no single types dominating the collection.
More than half of the artefacts in this unit show signs of weathering, including a fair number in weathering classes 2 and 3; however, at least three artefacts are clearly from the same raw material package, which may indicate that not all artefacts were reworked from primary deposits.

Unit 5 (Contexts 3 and 4) contained 71 artefacts: 33 quartz (46.5%), 36 quartzite (50.7%), and two pieces of fossil wood (2.8%). The quartz artefacts include a complete single platform core, a battered cobble (completely decorticated), two complete flakes (SC 7), nine flake fragments, and 20 pieces of angular shatter. The quartzite fraction includes three radial cores (SC 6-9), a broken core of indeterminate flaking, four complete flakes (avg. SC 4.5), 17 flake fragments, and 15 pieces of angular shatter. Among all flakes, most have cortical or plain platforms and bidirectional orthogonal or unidirectional flaking. Fourteen of the quartzite artefacts are clearly from the same raw material package, though none refit. Artefacts in this unit are variably weathered.

Unit 4 (Contexts 5 and 6) produced 60 artefacts: 38 quartz (63.3%) and 22 quartzite (36.7%). The quartz artefacts include 22 complete and fragmentary flakes and 16 pieces of angular shatter. The quartzite artefacts include 15 complete and fragmentary flakes, six pieces of angular shatter, and a unifacially flaked radial core or convergent end chopper. Quartzite objects are slightly larger on average than quartz objects (complete flakes avg. SC 6 vs. SC 5). Quartzite flakes also show a slightly greater variety of flaking styles, with more types of platforms/platform preparation and core reduction. This unit also shows a trend of increasing quartz utilization with depth, and slightly less weathering than in the units above.
Unit 3 (Context 7) contained 32 artefacts: 16 quartz (50%) and 16 quartzite (50%). Quartz artefacts include one casual core/tested cobble, ten flake fragments, and five pieces of angular shatter. Quartzite artefacts include two complete cores (SC 7), a radial core and a centripetal Levallois core, two complete and ten fragmentary flakes, and two pieces of angular shatter. The quartz flake fragments have cortical and plain platforms, and with an averages size class of 5.2, are slightly larger than similar artefacts in the quartzite sample (avg. SC 4.4). Quartzite flakes also have more dihedral platforms, which is typical of radial core reduction. Only two of the artefacts in this unit lack signs of weathering, so this may be a secondary deposit.

Units 1 and 2 (Contexts 9 and 10) have a combined total of six artefacts: one unworked chert or mudstone nodule, one quartz flake fragment, two quartzite flake fragments, and two complete quartzite cores—a single platform core and a radial or Levallois core.

**SSTP 13**

<<Unit 7 (very coarse sandy loam) produced the largest concentration of artefacts in TP 13, though the three units below it also contain artefacts. Within these four units, the absolute number and relatively frequency of quartz artefacts decreases, though the quartzite fraction remains relatively constant. Unit 7 contains refitting artefacts and other artefact groups from distinct toolstone packages, suggesting this layer suffered little post-depositional reworking (Figure 50). It also appears that platform reduction is more common in the upper portions of the pit, and radial reduction more common in the lower artefact-bearing units.>>

![Figure 50](image.png) Raw materials by context in SS TP 13.
Unit 8 (Context 1) produced one piece of quartz angular shatter. Unit 7 (Contexts 2 and 3) produced 103 artefacts: 68 quartz (66%), 31 quartzite (30.1%), three mudstone (2.9%), and one chert (1%). The quartz artefacts include one radial core (SC 9), one complete and eleven fragmentary flakes, and 55 pieces of angular shatter. Sixty-four percent of the quartz flakes have cortical platforms, followed by plain and dihedral platforms; most flaking is unidirectional or bidirectional orthogonal, which could indicate platform or radial flaking. The quartzite artefacts include two single platform cores (SC 9, 11), three complete and 14 fragmentary flakes, and thirteen pieces of shatter. Quartzite flakes have cortical, dihedral, and plain platforms, and represent both early and later stages of core reduction. Twelve of the quartzite fragments are from the same cobble, and though only four refit, these indicate single platform core reduction. The quartzite flakes and fragments are also on average two full size classes larger than similar quartz objects. The single chert piece is a flake fragment, and the mudstone artefacts include a single platform core (SC 10) and two flake fragments, one of which is non-refitting but clearly from the core. Most of the artefacts are unweathered, and in combination with the refitting pieces, it is a reasonable conclusion that this is a relatively intact primary deposit.

Unit 6 (Contexts 4 and 5) yielded 68 artefacts: 45 quartz (66.2%), 22 quartzite (32.4%), and one piece of chert shatter (1.4%). The quartz fraction includes a multiplatform core, five complete and 13 fragmentary flakes, and 26 pieces of shatter. The quartzite pieces include a casual single platform core, a radial or bifacial single platform core, five complete and nine fragmentary flakes, and six pieces of shatter. The complete quartzite flakes are, on average, one size class larger than the quartz flakes (SC 5.2 vs 4.2). Flakes on both materials show a fairly even mix of plain and cortical platforms, and most have unidirectional flaking. Artefacts in this unit are slightly more weathered than those in the unit above, but similar to the weathering in both of the units below.

Unit 5 (Context 6) yielded 64 artefacts: 33 quartz (51.6%) and 31 quartzite (48.4%). The quartz artefacts include five radial and one bifacial single platform cores, 15 complete and fragmentary flakes, and 12 pieces of angular shatter. Quartzite artefacts include a
multiplatform core, a radial core, 20 complete and fragmentary flakes, and nine pieces of shatter. Flakes in both raw materials show greater evidence of radial reduction: dihedral and plain platforms and centripetal and bidirectional orthogonal flaking. In contrast to Unit 6, quartz artefacts in Unit 5 are not on average significantly smaller than the quartzite artefacts, and in some classes, are actually larger.

Unit 4 (Contexts 7 and 8) is lowest artefact bearing deposit in TP 13, and produced 56 artefacts: 27 quartz (48.2%) and 29 quartzite (51.8%). Five quartz cores were found—two radial, one unifacial and one bifacial single platform core, and one casual core—in addition to a quartz cobble that was both flaked and used as a hammerstone/percussor (evident by concentration of pecking and spalling on one surface). Seven quartz flake fragments of a variety of flaking styles and 14 pieces of angular shatter were also found. The quartzite artefacts include three radial cores, 18 complete and fragmentary flakes, and eight pieces of shatter.

**SSTP 14**

<<The main artefact layer in TP 14 is in Unit 5 (poorly sorted gravel with pebbles), which is dominated by quartz artefacts and radial reduction (Figure 51).>>

Unit 8 (Contexts 1 – 6) yielded only eight artefacts: one complete flake, three flake fragments, and four pieces of angular shatter. Units 7 and 6 are similarly sparse—Unit 7 (Context 7) produced a single quartz flake fragment, and Unit 6 (Context 8) produced one quartz flake fragment and one piece of quartz angular shatter.
Unit 5 (Context 9) is a considerably denser accumulation of artefacts, with a total of 206 pieces: 130 quartz (63.1%), 75 quartzite (36.4%), and one complete fossil wood flake (0.5%). The quartz artefacts include two radial cores, one battered cobbled, seven complete flakes (avg. SC 4.3), 46 flake fragments, and 74 pieces of angular shatter. Quartz flakes predominantly have cortical or plain platforms and unidirectional or bidirectional orthogonal flaking, and the majority retain some degree of cortex. The quartzite artefacts include two radial and two single platform cores, one complete and 40 fragmentary flakes, and 30 pieces of angular shatter. Patterns of reduction on quartzite flakes are similar to the quartz flakes, but also include some centripetal/Levallois components. Approximately half of the artefacts in this unit are minimally weathered (WC 1), while the rest are fresh.

Unit 4 (Contexts 10 and 11) is the lowest artefact-bearing layer, with a total of 33 artefacts: 15 quartz (45.5%) and 18 quartzite (54.5%). Quartz finds include eight flake fragments and seven pieces of shatter. The quartzite objects include a multiplatform core/battered cobbled, six complete and seven fragmentary flakes, and four pieces of shatter. Among both raw material types, cortical platforms on flakes predominate, though plain, dihedral, and point platforms are also present; no single flaking pattern dominates the assemblage. Artefacts in Unit 4 are generally more weathered than those in the units above.

**SSTP 15**

<<Unit 3 (pebbles and cobbles) is the main artefact layer in TP 15, and has only slightly more quartz artefacts than quartzite artefacts (Figure 52). More quartzite cores were found than in quartz, but these show a significant degree of platform reduction; quartzite flakes also show significant differences in reduction

![SS TP 15 artefacts](image)

**Figure 52** Raw materials by context in SS TP 15.
sequence position and/or flake preparation and removal, which may indicate that reduction styles vary according to raw material in this unit.>>

Unit 4 (Context 1) of TP 15 yielded 34 artefacts: 17 quartz (50%) and 17 quartzite (50%). The quartz fraction includes a multiplatform core or battered stone, five complete and fragmentary flakes, and 11 pieces of angular shatter. The quartzite fraction includes a broken bifacially worked core, a small radial core, ten complete and fragmentary flakes, and five pieces of angular shatter. Quartz artefacts are larger on average than their quartzite counterparts (flake fragments avg. SC 5.7 vs. 4.7; shatter avg. SC 5.4 vs. 4). As a collection, the artefacts in Unit 4 are minimally weathered.

Of the 77 artefacts found in Unit 3 (Contexts 2 and 3), 42 (54.5%) are quartz and 35 (45.5%) are quartzite. The quartz artefacts include one broken radial core and two tested cobbles, three complete and 15 fragmentary flakes, and 21 pieces of angular shatter. The quartzite portion includes four single platform cores, one multiplatform core, one radial core, four complete and 18 broken flakes, and 7 pieces of angular shatter. Fifty percent of the discernable quartz platforms are cortical, 44% plain, and 6% each dihedral and faceted. This is in contrast to the quartzite flakes, where 80% of platforms are cortical, 15% plain, and 5% dihedral. Quartzite flakes are predominantly unidirectionally flaked, whereas a greater variety exists for quartz flakes—unidirectional, bidirectional, and centripetal flaking are all represented. Artefact types are generally comparable in size between the two raw material types, and so the variance in flaking method is not entirely size-dependant. The prevalence of cortical components among the quartzite artefacts may suggest that quartz cores were coming into the area partially reduced, while quartzite cores were relatively unworked.

Unit 2 (Contexts 4-5) is comprised of 23 artefacts: 9 quartz (39.1%) and 14 quartzite (60.9%). The quartz artefacts include a bifacial single platform core, a roughly radial core, four complete and fragmentary flakes, and three pieces of angular shatter. The quartzite artefacts include a single platform core, a double platform core, a multiplatform core, six complete and fragmentary flakes, and five pieces of angular shatter. The artefacts in this unit are considerably weathered, and it is likely that they have been subjected to significant translocation.
SSTP 16

<<The most artefact-dense layer in TP 16 is Unit 4, which is predominantly quartz and lacks a single defining reduction strategy (Figure 53). Among the finds, however, is a unique prismatic quartzite core with many refitting flakes, highlighting the variability of flaking strategies evident in this unit.>>

Unit 5 (Context 1) produced only 16 artefacts: 14 quartz (87.5%), one complete quartzite flake (6.25%), and one fossil wood flake fragment (6.25%). Quartz artefacts include two flake fragments and 12 pieces of angular shatter. Artefacts from this layer are unweathered, and while an uppermost unit like this is likely to have been significantly reworked, four of the quartz artefacts are clearly made on the same material, coming from a single quartz core. It therefore appears that this unit is at least partially intact.

Unit 4 (Context 2) produced a total of 136 artefacts: 94 quartz (69.1%) and 42 quartzite (30.9%). The quartz artefacts include a bifacial single platform core (SC 5), a fairly unsuccessful multiplatform core (SC 15), four complete and 32 fragmentary flakes, and 56 pieces of angular shatter. The quartzite portion includes a broken radial core (SC 5), a double (orthogonal) platform core (SC 8), a prismatic core (SC 7), six complete and 18 fragmentary flakes, and 28 pieces of angular shatter.
incomplete flakes, and 15 pieces of angular shatter. Twelve of the quartzite flakes and shatter refit onto the prismatic core (Figure 54), the form of which is unique among the MEMSAP excavated artefacts, but is typologically similar to prismatic (blade) cores from some South African MSA sites such as Klasies (Wurz 2002). Among quartz and quartzite flakes (not refitting to the prismastic core), flakes are either bidirectional orthogonally or unidirectionally flaking, and cortical or plain platforms, though quartz flakes also have a high incidence of dihedral platforms. Approximately one-third of the artefacts in this layer show minimal weathering, but considering the number of refitting pieces, this unit seems largely intact (Figure 55).

Unit 3 (Contexts 3 – 5) contained 79 artefacts: 58 quartz (73.4%) and 21 quartzite (26.6%). The quartz objects include two possibly tested cobbles (SC 10), a (failed) casual/radial core (SC 6), 17 flake fragments, and 38 pieces of angular shatter. The quartzite portion includes one complete and 11 fragmentary flakes and nine pieces of angular shatter. Flakes in both materials show a mix of flaking patterns, though the majority have cortical platforms. Quartzite artefacts are on average slightly larger than quartzite artefacts (flake frags. avg. SC 4.3 vs. 3.6; shatter avg. SC 3.7 vs. 2.8).

Only seven artefacts came out of Unit 2 (Contexts 6 and 7): one mudstone flake fragment, one complete quartz flake, one complete quartzite flake, and four quartzite cores: two tested or casual cores, one radial core (SC 6), and one radial/possibly Levallois core-on-flake (SC 9). The size bias of the artefacts in this unit may indicate that smaller portions have been transported away; weathering on the artefacts suggests a similar level of disturbance/reworking (WC 1 = 28.6%; WC 2 = 71.4%).

Sadala South Test Pit 17

No artefactual finds were recovered from TP 17.
Chaminade Survey Test Pits

<<CS Test Pits 14 – 17 show slightly higher incidences of platform reduction and core-on-flake production than many of the test pits from the rest of the Chaminade Survey area; they also significant variability in weathering of artefacts and size of artefact classes between and within test pits.>>

CSTP 14

Unit 2 (Context 1) produced a total of 32 artefacts: 19 quartz (59.4%) and 13 quartzite (40.1%). The quartz artefacts include one complete (SC 4) and six fragmentary flakes and 12 pieces of angular shatter. The quartzite artefacts include one complete (SC 5) and seven fragmentary flakes and five pieces of angular shatter. Quartzite artefacts are typically larger than quartz artefacts (flake fragments avg. SC 4.6 vs. 4.3; shatter avg. SC 3.8 vs. 2.6), and artefacts show a mixture of weathering classes (WC 0 = 14, WC 1 = 6, WC 2 = 10). As these objects are associated with top soil, it is likely this is a highly disturbed context.

Unit 1 (Contexts 2 – 9) produced only 14 objects, and these were found in only the upper portion of the unit (Contexts 2 – 5): 7 quartz (50%) and 7 quartzite (50%). The quartz fraction includes one radial core (SC 6), six fragmentary flakes, and five pieces of angular shatter. The quartzite portion includes one complete and one fragmentary flake. As in Unit 1, weathering in this unit is variable, and given the small sample size, further interpretation of the finds is limited (Figure 56).
CSTP 15
Unit 4 (Context 1) produced a total of 42 artefacts: 22 quartz (52.4%) and 20 quartzite (47.6%). The quartz artefacts include one complete and seven fragmentary flakes (avg. SC 3) and 14 pieces of angular shatter (avg. SC 3.2). Eighty percent \( (n = 4) \) of the discernable platforms on the quartz flakes are cortical. The quartzite artefacts include a broken single platform core (SC 12), two complete flakes (SC 2, 5), twelve fragmentary flakes (avg. SC 3.75), and five pieces of angular shatter (avg. SC 4.2). Like the quartz flakes, quartzite flakes have predominantly cortical platforms. Only four of the artefacts in this unit (9.5%) show signs of weathering (WC 1).

Unit 3 (Contexts 2 and 3) is the main artefact concentration in TP 15, with a total of 334 artefacts: 148 quartz (44.3%) and 186 quartzite (55.7%). The quartz artefacts include three possibly tested cobbles, five complete platform cores (two double platform, two multiplatform, and one bifacial single platform), eleven complete flakes, 48 flake fragments, and 81 pieces of angular shatter. The quartzite objects include three possibly tested cobbles, twelve complete and broken cores (eight single platform, two double platform, one multiplatform, and one casual), 23 complete flakes, 85 flake fragments, and 63 pieces of angular shatter (Figure 57). Among the flakes with discernable platforms, frequency differences are evident between raw material types—quartz flake platforms are 49% cortical \( (n = 24) \), 40.8% plain \( (n = 20) \), 4% dihedral \( (n = 2) \), 4% dihedral/cortical \( (n = 2) \), and 2.1% faceted \( (n = 1) \); quartzite flake platforms are 74.5% cortical \( (n = 35) \), 17% plain \( (n = 8) \), 6.4% dihedral \( (n = 3) \), and 2.1% dihedral/cortical \( (n = 1) \). Quartzite flakes and flake fragments also typically have more cortex on their dorsal surfaces, and are larger than similar quartz types (complete flake avg. SC 5.3 vs. 4.4; flake fragment avg.
SC 4.6 vs. 3.7; angular shatter avg. SC 4.3 vs. 3.8). It is likely that these differences are due to cobble size, with larger quartzite cores having a larger surface area for the removal of cortical flakes. Artefacts in this unit are generally fresh (WC 0 = 78.4%; WC 1 = 21%; WC 2 = 3.3%; WC 3 = 0.3%), suggesting minimal post-depositional reworking of the artefacts.

**CSTP 16**

Unit 2 (Context 1) yielded a total of 758 artefacts: 150 quartz (19.8%), 600 quartzite (79.1%), five chert (0.7%), and three fossil wood (0.4%). The quartz objections include a bifacial single platform or radial core, a small broken single platform core (for the production of bladelets?), three complete (avg. SC 3.3) and 36 fragmentary flakes (avg. SC 2.8), and 109 pieces of angular shatter (avg. SC 2.8). Quartz flake platforms are predominantly plain and dihedral. Quartzite artefacts include nine cores (two Levallois cores-on-flakes(?), two single platform cores-on-flakes(?), one bifacial single platform core, two multiplatform core, two indeterminate cores, and one broken radial/Levallois(?) core), 24 complete flakes (avg. SC 4.0), 279 fragmentary flakes (avg. SC 3.5), and 288 pieces of angular shatter (avg. SC 3.3). Quartzite flake platforms (total \( n = 255 \)) are 43.1% cortical (\( n = 110 \)), 36.5% plain (\( n = 93 \)), 13.3% (\( n = 34 \)), 4.3% dihedral/cortical (\( n = 11 \)), 2.4% faceted (\( n = 6 \)), and 0.4% point platforms (\( n = 1 \)); this significant proportion of cortical platforms is in distinction to those on quartz. Artefacts in this unit are minimally weathered, with approximately 43% of artefacts categorized as weathering class 1. While Unit 2 contains the densest artefact concentration, its position within the topsoil of the unit means that it may be a fairly disturbed context (Figure 58).
Unit 1 (Context 2) contains only 58 artefacts: 17 quartz (29.3%) and 41 quartzite (70.7%). The quartz artefacts include two casual cores and one indeterminate core, five flake fragments, and nine pieces of angular shatter. The quartzite fraction includes a single platform core, a multiplatform core, two recycled cores on flakes, two radial or centripetal Levallois cores, five complete and 15 fragmentary flakes, and 15 pieces of angular shatter. On all flakes, platforms are primarily plain and cortical, and flaking patterns are variable. While significant differences do not exist in the sizes of artefact classes within this unit, artefacts from Unit 1 are significantly larger than their Unit 2 counterparts: complete flake avg. SC 6.8, flake fragment avg. SC 6.2, shatter avg. SC 6.1. Approximately half of the Unit 1 artefacts have a weathering class of 1.

**CSTP 17**

Uppermost Context 1 spans Units 3 and 2, but will be considered here as part of Unit 2; Unit 3 is then devoid of artefacts. Unit 2 (Contexts 1 – 3) contains 77 artefacts: 61 quartz (79.2%) and 16 quartzite (20.8%) (Figure 59). The quartz component includes one possible flake and 60 pieces of angular shatter (avg. SC 3.1). The quartzite artefacts include one flake fragment and 15 pieces of angular shatter (avg. SC 3.1). Most artefacts in this unit are in weathering classes 1 or 2, so it seems that the artefacts in this layer are significantly displaced.

The 15 artefacts in Unit 1 (Contexts 4 – 6) are similarly weathered, and include 14 quartz and one quartzite piece of possible angular shatter.
Bruce Surface Collection Study

In 2012, several thousand artefacts were collected from the surface of the newly identified Bruce site. A 5x8m grid was established and all of the artefacts on the surface were systematically collected and plotted using a total station. A total of 4739 artefacts were collected from this grid in 2012. In 2014, this same exercise was repeated, and a total of 2122 artefacts were collected from the same grid. Two seasons of rains contributed to the exposure of the 2014 collected artefacts, and the combined data sets from the two years of collection have the potential to clarify the effects of weather systems on the erosion/deflation of open-air sites and the consequences for artefact assemblages. With the assistance of the laboratory crew and other members of MEMSAP staff, the collected artefacts were assessed for size class and weathering class, and this data was then entered into Excel files for later correlation with GIS data. A total of 3070 artefacts from 2012 and 2335 artefacts from 2014 were coded; clearly this numbers are at odds with the number of artefacts plotted by total station, so further work is necessary to sort out the data sets from this area. However, preliminary work on the GIS data sets produced in the field has produced an extensive surface for the surrounding area (see below), and for the Bruce site (Grid and Area I, inset).

Whilst revisiting the site named Bruce, it was noticed that an area that was collected of all surface artefacts had eroded over the last two years and re-exposed new artefacts from a lower deposit. This is of interest because it shows a continuation of site transformation over time, which could also be measured and compared to previous data (Figure 60). The site was surface collected with topographic shots taken with a total station, for comparison to 2012.
The combined spatial and attribute data sets were then analyzed and visualized in ArcGIS (both ArcMap and ArcScene). The following steps were followed to reveal the patterns in the spatial relationships between artefacts and surface deflation:

1) A Triangular Irregular Network (TIN) was created in ArcGIS using all total station-plotted points from the 2012 surface collection and topographic study; the same was done with all plotted points from 2014, resulting in two surface layers. Artefacts were plotted within the gridded collection area, according to size class coding (Figure 61).

2) The TINS were converted into raster datasets, preserving continuous elevation data across the study area. The Raster Calculator tool was used to determine the difference in elevation between the two rasters, showing the amount of erosion/deflation that occurred in the two years between collection activities.
3) Artefact points from each collection year were aggregated in 25x25cm squares across the main study area using the Spatial Join functionality, which generated choropleth representations of artefact density. The difference between these two vector classes was calculated in Excel, and reimported to ArcGIS, resulting in a layer showing the relative frequency of plotted artefacts between the two study seasons.

4) The two target layers—showing the variance in elevation and the variance in artefact distribution over the two study years—were overlain on the 2012 TIN surface in ArcScene to show the relationship between the variables.

In the two years between study seasons, artefacts were exposed through erosion/deflation in much the same distribution as seen in the 2012 collection (Fig. 5). While it is not clear how long the artefacts found during the 2012 collection had been exposed, it is possible that they have occupied that surface since J.D. Clark's archaeological investigations at the area in the 1960s. This underscores the primary goal of the study—to quantify the rate of exposure of subsurface artefacts in an area affected by seasonal monsoon systems—and certainly suggests that long time spans are not
necessary for erosional processes to influence significantly large surface scatters of artefacts.

To ascertain the effects of erosion on artefact exposure—or vice versa—two related datasets were generated. The first considers the change in elevation, which is a proxy for degree of erosion in the study area, and shows that erosion is not uniform across the site (Figure 62).

![Figure 62](image-url) Surface elevation change between the two years.

The second considers the relative distribution of artefacts between the two study years, the results of which can be seen in Figures (Figure 63). When these two datasets are overlain, the relationship between artefact cover and erosion is clearer, and suggests that dense artefact distributions serve to reduce or even halt erosion of a land surface, similar to the formation of an armored surface in fluvial geomorphology. Once exposed, artefacts act as stabilizing agents against erosional processes. While this in itself is perhaps not surprising, it does show a more nuanced relationship between subsurface and surface artefact densities, as it is often assumed that large surface scatters represent palimpsests of long-term erosion. Rather, dense surface scatters can be the result of diverse but equifinal processes.
This study of surface artefact distributions and rates of erosion demonstrate that multiple processes can lead to the accumulation of archaeological material on modern landscapes, and that rates of change in either variable are likely not uniform across open-air sites even in the same landscapes. Furthermore, this study points to the potentially destructive nature of archaeological investigation as a mechanism for inducing subsurface disturbance. Often, surface collections are undertaken in an effort to “preserve” or “protect” cultural material, but in doing so, archaeologists may unknowingly be initiating significant further damage to intact underlying and adjacent archaeological deposits. With the understanding of the possible extensive damage surface collection could impose on a site, field work could be tailored with better methodologies that ensure that in situ artefacts at significant sites could be better preserved for future analysis by leaving capping artefact scatters in place. Unfortunately, many important sites (including Bruce) are threatened by other processes, such as development and agriculture; thus, a balance must be struck between short-term mitigation and long-term protection.

CHA-III

Background

A preliminary examination of the artefactual material from the excavation Chaminade III (CHA-III) was made over four days in January 2015 (Jan 22-25). No analysis per se was undertaken – artefacts were removed from their lot bags, counted, and core and implement numbers were quantified. A quick appraisal of core and implement types was also made, though this was not systematic. The initial objective of the exercise was to select a sample for shipping and analysis in Australia, though it was decided during the four days that the entire assemblage should be shipped for study in 2015 and return in 2016. These notes serve to summarise observations made during the brief inspection.
The main excavation area at CHA-III comprises an inverted pyramid, tapering in towards the centre with depth. The squares were assigned alphanumeric co-ordinates, in rows A-D and from 1-7. The deepest excavated squares were in the centre of rows B & 7 - squares B3-5 and C3-5. The maximum depth obtained below surface is unknown but probably around 4 m. The deepest context numbers are 75-82. The deepest point in row A occurred in A3 at context 38; in row D no square seems go past context 25. In the 2013 season an extension to CHA III was opened to the north, comprising squares D94-98. The distribution of artefacts within these two excavations is illustrated in Figure 64.

**Figure 64** Distribution of artefacts according to depth. Because of the slope obscuring the patterning in profile view, only column D (yellow) and C (purple) are shown.

**Artefacts**

During November 2013, Mackay described individual artefacts from a sample of contexts in square C5. The sample suggested the presence of a Later Stone Age (LSA) component to the site, comprising a crystal quartz assemblage with small blades and backed artefacts. Below this, proportions of quartzite appeared to increase consistently into clear MSA layers, as did the size of flakes even within raw material classes. These observations suggested that CHA-III may have preserved an MSA/LSA transition.

The reasons for the observations made in January 2015 have been outlined above, but to reiterate, it was not an analysis but only a set of descriptions in preparation for sampling.
and shipping. No metrics and effectively no individual artefact characteristics were recorded. The plot data, however, do show some interesting preliminary patterns.

*CHA III*

With respect to the lithic sequence in CHA III, five main components were suggested by new observations in 2015, as follows:

**Contexts 1-5:**

Insufficient material for comment but this would belong to Unit 8 and would be highly disturbed.

**Contexts 6-12:**

High artefact densities, clear quartz dominant. Quartz is often outcrop-sourced, rather than river-derived. Cores platform and rotated with perhaps some remnant Levallois. Flakes seem quite bladey, e.g. typically longer than they are wide. Several backed pieces and some scrapers also noted. This component is probably LSA. It also appears to sit at the base of Unit 8, or at the contact between Unit 7 and Unit 8. In the plot data are expressed as a clear band sloping down to the north and west and the artefacts were likely discarded on a sloping landsurface or displaced from further upslope. The slope sits unconformably on underlying horizontally-bedded MSA material, suggesting new deposition after a period of erosion. It is conceivably Holocene. The coherence of the sample and its spatial distribution seem at odds with an assessment of it being a disturbed context.

**Contexts 13-25:**

These contexts contain the lowest artefact densities in the archaeologically-active part of the deposit. Apparent increase in quartzite, and some clear MSA artefacts. These include several Levallois points and pseudo-points. The distribution of these in the plot data (using context boundaries only, rather than individual finds) seems to be fairly linear and horizontal. There also seems to be a gap between these point-bearing contexts and the high density, backed-artefact bearing contexts. The density of artefacts in this gap is extremely low.
Contexts 26-40:

These contexts show moderate densities of artefacts, with further increases in proportions of quartzite. There are numerous MSA markers, but no clear sub-class identifiers (other than perhaps a few more blades). Cores are generally discoid and unifacial with some Levallois. There is little to no retouch.

The plot data show the distribution of finds in this part of the deposit occurring as a series of discrete lenses separated by a few cm, giving the plot a ‘dot matrix’ look. The tentative hypothesis is that the artefacts here represent occupation on or near a stream bank, with occupational events separated by periodic overbank sedimentation or episodic alluvial fan pulses.

Contexts 40-82:

These contexts are effectively sterile. The only artefact found in this part of the deposit had class 2/3 rounding. The absence of archaeology here is interesting, as artefact densities are quite high at an equivalent depth in the nearby Test Pit 7.

CHA IV Extension

There is again a very clear density band in the upper part of the deposit, expressed as line dipping down to the south and west. This band again contains an abundance of clear quartz artefacts made on outcrop-sourced pieces, small blades and backed artefacts. It is almost certainly a match for the corresponding microlithic band in the main excavation area. But, the slope is reversed. If extrapolated, CHA-III main and CHA-III extension seem to occur on either side of a small drainage depression, one which may be associated with the erosion of upper MSA sediments. Conceivably Unit 8 is then channel fill post-dating the active channel.

Second, the deepest excavated context (26^1) is archaeologically active, with high proportions of quartzite and MSA markers. These layers occur deeper than the lowest

---

^1 Contexts in the extension do not correspond with those in the main area; spits appear to have been thicker and thus context 26 in the extension is deeper than context 40 in the main area.
archaeologically-active sediments in the main area. Indeed, excavation in the extension ceased at context 26 without reaching any sterile layers.

**Discussion**

There are obviously complexities at and around CHA III. Archaeology occurs in deposits >57 ka at CHA III extension and Test Pit 7, but not at CHA III main area. We do not understand why, given that the main area and the extension are located only a few meters apart. However the cobble band (Unit 5) which seems to mark the base of the archaeology in the main area may not occur in the extension, and the cobbles in TP7 may be a different band entirely. Reconciling these will probably require close attention to the archaeology, allied with ages where possible.

**Future work**

The CHA-III sample preserves LSA and MSA elements, albeit possibly not the transition initially implied. Nevertheless, the MSA is quite variable and includes a late MSA component with Levallois points possibly analogous to those from the Bruce site. The site has excellent further research potential. Research should focus on characterising the MSA elements through morphometric and possibly refit analyses, and ultimately assessing the behavioural significance of CHA III at the landscape scale and relative to human evolutionary developments in the late Pleistocene.
Preliminary results from the Chaminade II (CHA-II) excavation that were made in 2014-2015 are presented in a summary in Table 6.

**Table 6** Summary of new phytolith and OSL results from CHA-II.

<table>
<thead>
<tr>
<th>EAST Profile</th>
<th>60cm vertical distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elev</td>
<td>Sample #</td>
</tr>
<tr>
<td>536.7</td>
<td>3200</td>
</tr>
<tr>
<td>536.5</td>
<td>3201</td>
</tr>
<tr>
<td>536.4</td>
<td>3202</td>
</tr>
<tr>
<td>536.3</td>
<td>3203</td>
</tr>
<tr>
<td>536.2</td>
<td>3204</td>
</tr>
<tr>
<td>536.1</td>
<td>3205</td>
</tr>
<tr>
<td>535.9</td>
<td>3206</td>
</tr>
<tr>
<td>536.0</td>
<td>3207</td>
</tr>
<tr>
<td>535.7</td>
<td>3208</td>
</tr>
<tr>
<td>535.6</td>
<td>3209</td>
</tr>
<tr>
<td>535.4</td>
<td>3209</td>
</tr>
<tr>
<td>535.2</td>
<td>3200</td>
</tr>
<tr>
<td>535.1</td>
<td>3201</td>
</tr>
<tr>
<td>534.9</td>
<td>11</td>
</tr>
<tr>
<td>534.8</td>
<td>12</td>
</tr>
<tr>
<td>534.6</td>
<td>13</td>
</tr>
<tr>
<td>534.5</td>
<td>14</td>
</tr>
<tr>
<td>534.3</td>
<td>15</td>
</tr>
<tr>
<td>534.2</td>
<td>16</td>
</tr>
<tr>
<td>534.0</td>
<td>17</td>
</tr>
<tr>
<td>533.8</td>
<td>18</td>
</tr>
<tr>
<td>533.7</td>
<td>19</td>
</tr>
<tr>
<td>533.6</td>
<td>20</td>
</tr>
<tr>
<td>533.4</td>
<td>21</td>
</tr>
<tr>
<td>533.3</td>
<td>22</td>
</tr>
<tr>
<td>533.2</td>
<td>23</td>
</tr>
</tbody>
</table>

**Base of Excavation**

- Arboreal dominant
- Change in lithology, artefact abundances, natural formations, and phytoliths
- Duplicate samples from opposing profiles; no need to sample
- OSL Age pending
In 2014 Julio Mercader began work in earnest on the phytolith assemblages from the excavated sites. His focus began with CHA-II in preparation for a manuscript that will be submitted in June 2015 to the *Journal of Archaeological Science*, for a special issue on tropical geoarchaeology. The profile and sample locations are shown in Figure 65.

Figure 65 Profile summary and sample locations from CHA-II.
VIII. SUMMARY

Summary and Conclusions

The 2014 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, although as always it was the case that new questions were raised as more information was obtained. This provides the basis for future work, for which funds will be requested in 2015, 2016, and 2017.

Excavation in the Sadala/Kesote area showed that this part of the Chitimwe Beds preserves intact deposits, with more than half of all test pits producing refitting artefacts. This contrasts with the Chaminade test pits, in which only a few have refits. The SS-I main site revealed a concentration of artefacts in association with a cobble horizon, rather than an accumulation of iron pan, which continues the pattern observed at many other sites in which artefacts were deposited upon surfaces that were subsequently buried, and usually appear to be in association with near-stream environments. Future work here should include a carefully excavated and plotted trench that links the SS-I site to the 2012 geological trench.

The survey revealed more detailed patterns in MSA stone artefact reduction and raw material abundances, specifically with respect to geology and raw material abundances. A significant new area was discovered in the southern part of Karonga, and because it is rapidly eroding it should be subjected to test-pitting and formal excavation in the near future. Its location far from the Sungwa Beds and in a more arid part of Karonga makes it an ideal complement to the excavations that have been done in the north.

In accordance with the timeline for research, several analytical tasks were also progressed. These include stone artefacts, geoarchaeology, OSL, ochre analysis, and spatial analysis. The focus will now be on preparation of these results for more publications, to aid in future requests for funding. As the primary investigator, Dr. Jessica Thompson, has moved to a new institution in the United States, major funding requests
must now be to different sources. Securing new funding will comprise a large part of her workload in 2015, as all other grants for MEMSAP have now been completed and final reports are due. The timing is therefore optimal to consider the next major phase in MEMSAP research.

The landscape approach taken in Karonga has been extremely fruitful, but because preservation in the lateritic sediments is poor it must be restricted to sedimentary analyses, OSL dating, artefact analyses, and (in some cases) phytolith analyses. Future work should focus on locating rock shelters that will provide more continuous and fine-scale sequences. As rock shelters in northern Karonga are lacking, survey should take place in the southern part of Karonga. This can be done in conjunction with excavations in the southern Chitimwe surface with the intact deposits that was located during 2014 survey.

Rock shelters with good bone preservation are known to be present in other Districts in Malawi, for example at Mount Hora in Mzimba (Clark 1966) and in Dedza (Clark and Clerk 1973, Crader 1984). Many of these have high cultural significance and their investigation would provide information of international importance that may make the work particularly appealing to funding agencies. In the near future, therefore, very small test-pits should be emplaced in known and new rock shelter sites in these two regions in order to obtain pilot data suitable for writing a large funding proposal. This proposal should also include an ancient DNA component, as several sites have reported human remains (Morris and Ribot 2006). This will enable future work to “put the people” together with the archaeology. Although this may result in an emphasis on the later part of Malawian prehistory, it has been found that in Karonga the majority of sites date to the Late Pleistocene. Therefore, known rock shelter sites may make a more appropriate comparative dataset to the abundant MSA materials of Karonga than had previously been suspected.

**Acknowledgements**

The authors firstly thank the Malawi Government for their continued support for the project. Permits were provided by Director of Culture Dr. Elizabeth Gomani-Chindebu
and Deputy Director of Culture/Director of Antiquities Ms. Chrissy Chiuma. In 2014 the crew comprised a mix of specialist scientists, professional staff, students, and an outstanding crew of local workers. Mr. Medson Makuru, Mr. Malani Chinula, Mr. Frederick Mapemba, and Mr. Joseph Tembo represented Malawi Antiquities in the field, with an inspection visit headed by Mr. Oris Malijani. We appreciate the continued support of the local community, especially this season from Chiefs Sadala and Kesote, and were pleased that our Archaeology morning was well-attended by the people of Karongga. The Cultural and Museum Centre, Karongga provided an excellent venue and encouragement for this public outreach program. We are very grateful to Prof. Friedemann Schrenk for assisting us with the storage of our field equipment. This season’s work was supported by The University of Queensland’s Archaeological Field School (funds to Thompson) and the University of Tübingen (funds to Miller). The University of Queensland has provided access to the technical equipment used over the life of the project so far.
IX. REFERENCES CITED


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Appendix 1: Outline of the 2014 MEMSAP Survey Module designed by FAIMS

TAB 1 – TRANSECTS

Transect attributes as described during the data modelling procedure and in the table below, including start and end points that are populated in WGS84 UTM using a “take from GPS” button.

New transect begins when EITHER Landform OR Geomorphic Summary changes

Track logs should also be available.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Measurements / categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transect number</td>
<td>001, 002, 003, etc.</td>
</tr>
<tr>
<td>Photo file number(s)</td>
<td>Every transect photographed</td>
</tr>
<tr>
<td>Landform</td>
<td>1) Range top; 2) Upper slope; 3) Middle slope; 4) Lower slope; 5) Flat land (not part of river or creek flat); 6) Hill (smaller than range top, not big enough to divide into upper, middle and lower slope); 7) River flat (floodplain); 8) Creek flat; 9) Long gradual slope; 10) Short steep slope</td>
</tr>
<tr>
<td>Remarks on landform</td>
<td>Comments such as: degrees of slope angles measured/estimated with a clinometer, incised stream valleys, size of landform, which geological characteristics are present on the geological map, e.g. Chitimwe, Chiwondo, Dinosaur Beds, etc</td>
</tr>
<tr>
<td>Average percentage of visibility of surface of the landform area</td>
<td>Visibility determined and recorded to the nearest 10 %, taking into account grass cover, leaf litter, etc.</td>
</tr>
<tr>
<td>Remarks on visibility</td>
<td>Comments such as: open patches, field, short or tall grass, trees, buildings, water surface, etc</td>
</tr>
<tr>
<td>Average percentage of exposure of artefacts</td>
<td>Exposure estimated to the nearest 10 % as the mean percentage of the surface area of the survey where erosion was sufficient to reveal objects on the surface of the ground.</td>
</tr>
<tr>
<td>Remarks on exposure</td>
<td>Comments such as: erosion and other things that can cause erosion; agricultural activity, grazing, road disturbance, etc</td>
</tr>
<tr>
<td>Basic geomorphic summary</td>
<td>1) Bedrock; 2) Lag on bedrock; 3) Lag on sediments; 4) Colluvium; 5) Alluvial fan; 6) Floodplain alluvium; 7) Fluvially incised sediments / strath terraces; 8) Other</td>
</tr>
<tr>
<td>Cobble distribution</td>
<td>1) Not present / very rare; 2) Evenly scattered; 3) Quite evenly / bit aggregated; 4) Aggregated</td>
</tr>
<tr>
<td>Estimated number of cobbles</td>
<td>Per m²</td>
</tr>
</tbody>
</table>
After discussion with a geomorphologist we thought a useful way for inexperienced people to describe changes in geomorphology might be:

**Sediment Size** (only tick those that comprise at least 20% of visible surface sediment) – Tick boxes with options Fine, Coarse, Small Clasts, Large Clasts and an annotation field

**Sediment Thickness** – radio buttons with < 10cm to Bedrock and >10cm to Bedrock as options and an annotation field

### TAB 2 – TRANSECT OBJECTS

Object (core and cobble) attributes as described during the data modelling procedure and in the table below, with x, y populated in WGS84 UTM using a “take from GPS” button…not sure what to do about the z dimension, unless elevation is an option?

The following are common attributes to both cores and cobbles:

**Artefact ID** – Number that needs to be unique, and perhaps should be tied to the specific transect?

**Object** - Radio button with values Core and Cobble

**Weight (g)** – can accept decimals

**Maximum length (mm)**

**Maximum width (mm)**

**Maximum thickness (mm)**

**Raw material** – drop-downs with the values Quartz, Quartzite, Chert, Silcrete, Other (describe) and an annotation and confidence box

**Crystal Size** – drop-downs with the values Fine, Medium, Coarse and Description should say “Estimated by using a sand gauge (©1984 W.F. McCullough)”

**Abundance of Flaws** – Drop-downs in increments of 10% and Description should say “Percentage of impurities mottles, large coarse fragments, and natural fissures measured on two spots on the inside of the cobble in a 2 x 2 cm square, using Munsell Charts for Estimating Proportions of Mottles and Coarse Fragments”

**Photo File Numbers**
Other Comments

The following is specific to cobbles and should appear when “Object” = “Cobble”

**Angularity** – drop-downs with the values Rounded, Sub-rounded, Angular, Sub-angular, Other (describe) and an annotation and confidence box

The following are specific to cores and should appear when “Object” = “Core”

**Completeness** – Radio button with options Complete and Broken

**Weathering stage** – Drop-down with following options (0) No edge rounding evident (1) Edge rounding visible under light magnification (2) Edge rounding visible to the eye, but no features of the artefact were obscured (3) Edge rounding obscured features of the artefact, including blurring of dorsal scar patterns and possible modification of artefact dimension

**Outer Surface (Cortex) on Whole Core** – Drop-down with values None, < 25%, 25 - 50%, 50 - 75%, > 75%

**Outer Surface (Cortex) on Upper Hemisphere** – Drop-down with values None, < 25%, 25 - 50%, 50 - 75%, > 75%, Not Applicable and in the Glossary define as “Face with the lowest amount of cortex”

**Outer Surface (Cortex) on Lower Hemisphere** – Drop-down with values None, < 25%, 25 - 50%, 50 - 75%, > 75%, Not Applicable and in the Glossary define as “Face with the highest amount of cortex”

**Number of Flake Scars** – Should be an integer and in the Glossary define as “All scars ≥ 10 mm in length and width”

**Number of Platforms** – Should be an integer

**Flaking on Core Perimeter** – Drop-down with values < 20%, 20-40%, 40-60%, 60-80%, > 75%, not applicable

**Typology** – Drop-down with values: Levallois, Disc, Discoidal, Single platformed - Unifacial, Single Platformed – Bifacial, Double Platformed - Opposed, Double Platformed at Right Angles, Multiple Platformed, Shapeless/Miscellaneous, Blade, Bipolar

**TAB 3 – MAP**

Map page that shows location of all points taken and with a description of each (e.g. A for artefact, C for cobble, T for transect)

**TAB 4 – TOTAL RECORDING**

No x, y, z needs to be entered here because each object will be mapped with total station. X, y, z fields can be there in case eventually it become possible to pull the data from the total
station (as they are now for plotted finds in the Excavation Module), but at the moment having the TS ID match what appears in each Artefact ID is sufficient.

**The following are common attributes to all artefacts:**

**Artefact ID** – Autonumber that needs to be unique, but how to ensure it is unique across multiple devices? These should be recorded in a separate table from objects that are described during transect-style recording.

**Photos** – embedded in the record with the “take photo” option

**Photo file numbers** – for external photographs of the same object

**Technological Component** - Radio button with values Flake, Core, Shatter/Flake Piece, Other and an annotation and confidence box

**Weight (g)** – can accept decimals

**Maximum length (mm)** – Description should say “For flakes, this must be measured longitudinally, e.g. from the platform to the termination”

**Maximum width (mm)** – Description should say “For flakes, this must be measured transversely, e.g. from one lateral margin of the flake to the other”

**Maximum thickness (mm)** – Include a radio button that says “Measurement site” and the options are “Bulb” or “Other (describe)”

**Raw material** – drop-downs with the values quartz, quartzite, chert, silcrete, other (describe) and an annotation and confidence box

**Weathering stage** – Options are 0, 1, 2, 3 as described for the other core attributes we record

**The following are specific to flakes and should only appear as options when “Technological Component” = “Flake”**

**Longitudinal Portion** – Drop-down with options Complete, Proximal, Medial, Distal

**Transverse Portion** – Drop-down with options Complete, Split Left, Middle, Split Right, Margin

**Platform Type** – Drop-down with options Cortical, Plain, Dihedral, Polyhedral, Faceted, Crushed/Shattered, Point

**Termination** – Drop-down with options Feather, Overshot, Hinge, Step

**% Cortical Coverage** – Drop-down with options 0-24%, 25-49%, 50-74%, 75-99%, 100%

**Typology** – Drop-down with options None, Levallois, Blade, Point, Backed and an annotation and certainty box
Scar Orientation – Drop-down with options Indeterminate, Levallois, Unidirectional, Bidirectional Opposed, Bidirectional Orthogonal, Centripetal

Number of Dorsal Scars – Can only take an integer

Retouched – Radio button with Yes (describe) and No as options and an annotation and certainty box. In the Description/Info text write “Describe the retouch, e.g. invasive, non-invasive, steep, shallow, etc.”

Comments – Text box

The following are specific to cores and should only appear as options when “Technological Component” = “Core”

Exactly as above with the Transect Objects when they = “Core”

The following are specific to shatter/flake pieces and only appear as options when “Technological Component” = “Shatter/Flake Piece”

% Cortical Coverage – Drop-down with options 0-24%, 25-49%, 50-74%, 75-99%, 100%

The following are specific to other stone artefact classes and should only appear as options when “Technological Component” = “Other”

Other Type – Drop-down with options Manuport, Hammerstone, Grindstone