KOKODA INITIATIVE – ARCHAEOLOGICAL REPORT ON FIELDWORK IN MADILOGO 16-26TH JUNE 2014

Submitted
9/9/2014

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DEPARTMENT OF ENVIRONMENT AND CONSERVATION

KOKODA INITIATIVE ARCHAEOLOGICAL REPORT ON FIELDWORK IN MADILOGO 16-27TH JUNE 2014

Dr Matthew Prebble, Dr Matthew Leavesley & Mr Alois Kuaso

08 September 2014

A report by
ANU Enterprise Pty Ltd

Key to images in previous plate: Upper left: Community consultation meeting at (Ma i) Madilogo; Upper right: key artefacts from Eialogo excavation; Middle left: Frank Rabi in Eiaiafaha excavation; Middle right: Ebologo hamlet. Lower left: collection of okari nuts (*Terminalia kaernbachii*) below a tree ready for cracking in Ma i Madilogo; Lower right: freshly cracked okari nuts near Eialogo.

TEAM COMPOSITION

Dr Matthew Leavesley	Research Fellow, School of Arts and Social Sciences, James Cook University, Cairns Campus, Australia
Alois Kuaso	Curator, National Museum and Art Gallery, Boroko, Papua New Guinea
Malcolm Keako	Senior Program Officer, Department of Environment & Conservation, , Papua New Guinea
Dr Matthew Prebble	Research Fellow, Archaeology & Natural History, School of Culture History and Languages, College of Asia & Pacific, The Australian National University, Canberra, Australia

08 September 2014

A report by ANU Enterprise Pty Ltd for Department of Environment and Conservation (Papua New Guinea Government, Port Moresby) and the Department of Sustainability, Environment, Water, Population and Communities (Australian Government, Canberra)

EXECUTIVE SUMMARY

This report presents a provisional summary of archaeological excavations conducted in the surrounds of Madilogo (Ma i) as part of a study commissioned by the Department of Environment and Conservation as a Kokoda Initiative activity. Excavation site selection was based on previous predictive modelling and extrapolated evidence collected from previous fieldwork at Kosipe, Kokoda, and Madilogo excavations. The aim in this approach was to capture as many different potential site types as possible within the Naoro Valley and to improve our predictive modelling capacity for further archaeological research within the Kokoda Interim Protection Zone. Excavations were carried out in the currently occupied village of Ebologo and three older unoccupied locations including Eiaiafaha (near Tubelogo), Eialogo and Dabonumu. Eiaiafaha is the lowest elevation site at ~650m and Dabonumu the highest at ~1150m, a ridge line site identified by the people of Madilogo as the oldest ancestral village in the area. Over one hundred artefacts, including stone axes, flakes and exotic source stone, were excavated highlighting the richness of this archaeological landscape. From our preliminary analyses we have identified the first lower-montane (500 to 1500m in elevation), stratified and open archaeological sites in Papua New Guinea. At least two of these sites reflect village occupation contemporaneous with an arboricultural based economy dated to around 2800 years ago. We have also identified the earliest stratified evidence of long-distance stone tool exchange in the Owen Stanley Ranges and the Papuan Peninsula.

Evidence for an exchange network with coastal communities and the Naoro River Valley, is demonstrated by the presence of a stratified obsidian flake sourced to West Fergusson Island (Milne Bay Province). This flake is associated with radiocarbon dated material to 2800 years ago from Eialogo at ~800 m in elevation. We hypothesise, based on another obsidian flake found at Dabonumu, that a similar age for this exchange network may extend to a much wider area of the Owen Stanley Ranges. Interestingly, this exchange connection began soon after Lapita occupation of the South Coast at Caution Bay. It is possible that this connection may have extended from the north into the Naoro Valley from the Kokoda Valley in Oro Province.

Along with the obsidian flake finds, we identified abundant basaltic, metamorphic and quartz stone flakes and a single flake of chert, probably from a coastal source, reinforcing a hypothesis of strong exchange networks with coastal communities over the last 2800 years. We suggest that there is a favoured stone tool material, given its abundance and presence in all excavated sites, indicating the probable presence of a stone quarry in close proximity to or within the Naoro Valley. It is also possible that the basal deposits of two of the excavated sites may hold pre-agricultural material given the diversity of basaltic source material and contrasting tool manufacturing techniques.

Further finds of surface stone artefacts, to that described in our earlier report (Prebble et al 2013), provide evidence of widespread occupation preceding the modern inhabitants extending back to at least 2800 years ago. The presence of numerous nut anvil stones found at the base of living *Terminalia kaernbachii* (okari) trees, used for the nut cracking by the people of Madilogo reflect the modern importance of this crop. One possible anvil stone was located in the Eialogo deposits, associated with okari *Terminalia* type microfossils dated to 2800 years ago, and this may indicate the initial establishment of cultivated groves.

A set of recommendations based on the results of our archaeological excavations is provided.

TIMELINE

Date	Persons	Item
15 June	Prebble& Leavesley	Arrive in Port Moresby
16 June	Prebble, Leavesley, Kuaso & Keako	Depart via helicopter to Madilogo at 10am; community consultation meeting at 2pm; 3pm Survey of Eiaiafaha
17 June	Prebble, Leavesley, Kuaso & Keako	Excavation at Eiaiafaha
18 June	Prebble, Leavesley, Kuaso & Keako	Excavation at Eiaiafaha
19 June	Prebble, Leavesley, Kuaso & Keako	Excavation at Eiaiafaha
20 June	Prebble, Leavesley, Kuaso & Keako	Excavation at Ebologo
21 Jun	Prebble, Leavesley	SDA Lotu Day: Prebble & Leavesley consolidate notes & wash artefacts
22 June	Prebble, Leavesley, Kuaso & Keako	Excavation at Ebologo
23 June	Prebble, Leavesley, Kuaso & Keako	Team walks to the caldera of Madilogo Volcano, then to Dabonumu to survey & excavate
24 June	Prebble, Leavesley, Kuaso & Keako	Excavation at Eialogo
25 June	Prebble, Leavesley, Kuaso & Keako	Excavation at Eialogo
26 June	Prebble, Leavesley, Kuaso & Keako	Depart via helicopter for Port Moresby at 1pm, 4 hour delay; Prebble & Leavesley compile summary of notes for meeting with DEC staff. Kuaso writes NMAG export permit
27 June	Prebble & Leavesley	Meetings with DEC staff (James Sabi, Mark Nizette and Malcolm Keako) discussing results of field work. Meeting with Mr Alois Kuaso to complete requisite paperwork formalities.
28 June	Prebble & Leavesley	Depart for Australia

ACKNOWLEDGEMENTS

We thank Malcolm Keako, Elton Kaitokai, James Sabi and Mark Nizette at the Department of Environment and Conservation, (Papua New Guinea Government, Port Moresby) and Joyce Onguglo of ANU Enterprise Pty Ltd. We are also indebted to Mark Walker, who conducted the GIS predictive analysis and the phytolith analysis of the Eialogo section and Clair Harris, who conducted the technological analysis of the artefact assemblages.

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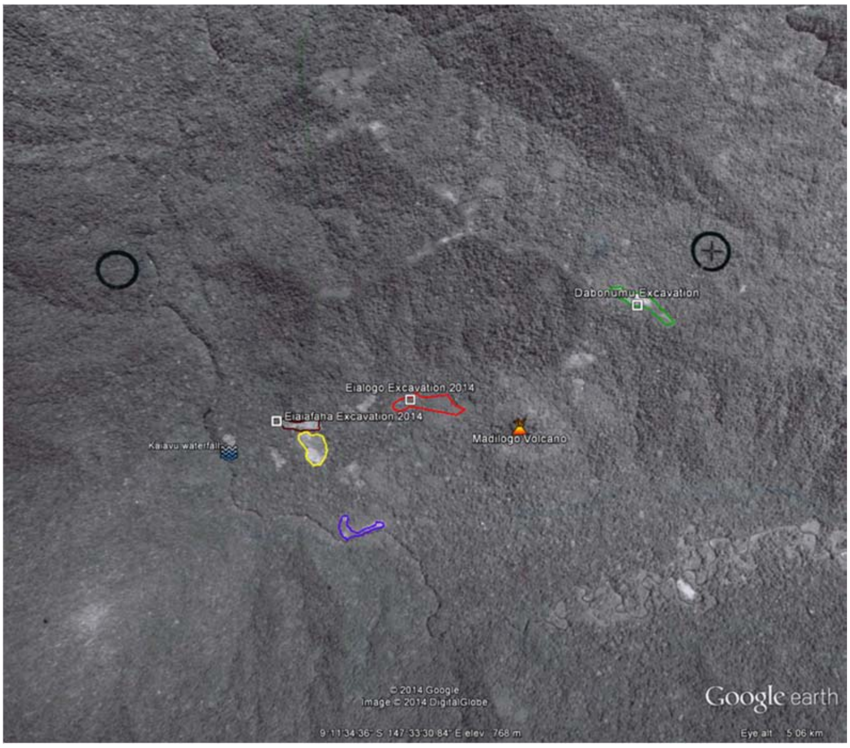
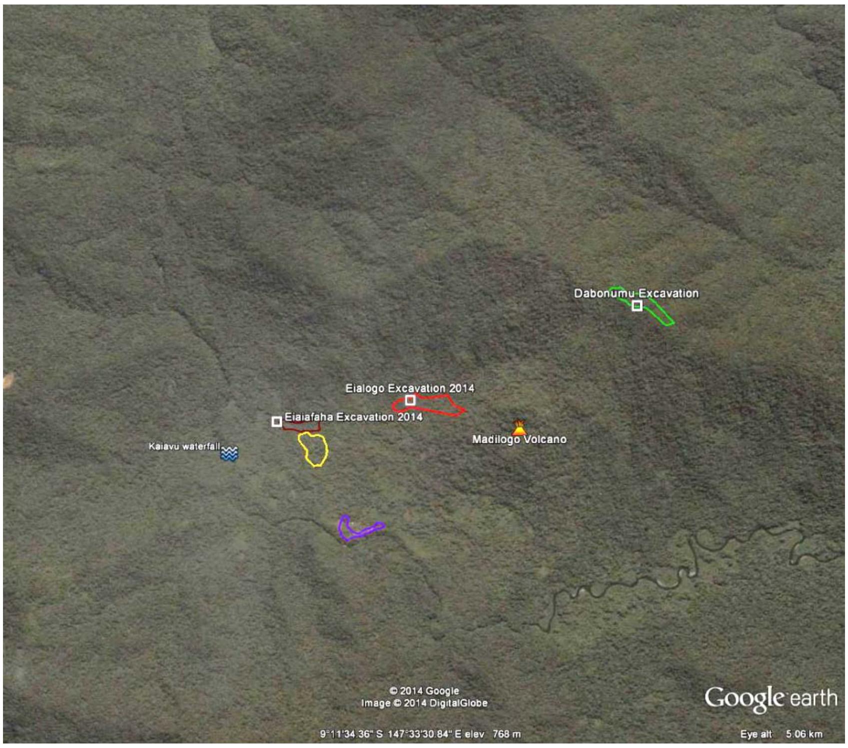
FRONTISPIECE





Area of Interest (AOI) and immediate surrounds of Ma i Madilogo Village (Purple). The AOI is situated within Ward18 of the Koiari Rural LLG. Upper image is from the Australian Airforce 1956-57 aerial survey and the lower image is from Google Earth 2001 and lower image. Also outlines are Eialogo (red), Old Madilogo (yellow), Eiaiafaha and Tubelogo (dark red) and Dabonumu (green).

MADILOGO TRAVEL DIARY JUNE 15TH - 26TH 2014

Team: Alois KUASO (NMAG), Malcolm KEAKO (DEC), Matt LEAVESLEY (JCU), Mat PREBBLE (ANU)

Village field workers: Frank Rabi, Rex Bamave, Elijah Ezekiel, Gideon Sibi, Sobi Ladive, Robert Sam, Tuksy Negoa, Badie (Agulogo), Jo (Ebologo)

16th June

9am Pacific helicopter from Jackson's Airport to (*Ma i*)[1] *Madilogo* arriving at 9:30. Clear conditions

Met with all the residents of (*Ma i*)*Madilogo* and immediately began formal discussions with **Frank Rabi**(the village magistrate)

We were accommodated in Frank Rabi's house.

Continued with informal discussions with RABI about our program.

1pm Meeting with the entire *(Ma i)Madilogo* Village. KUASO discussed the role of NMAG and presented the excavation permit. KEAKO discussed the role of DEC and the Kokoda Initiative project and the plans for development and the need for archaeological work. LEAVESLEY discussed the meaning of archaeology and its importance for the Mountain Koiari. PREBBLE discussed the results of the 2012 archaeological survey.

3pm Team visits Eiaiafaha, a river-side section of old Madilogo village, as the initial selected site for archaeological excavation. Team also visits a site where a mokmok stone disc was located by Rex Bamave

17th June

8am – Team departs for initial excavations at Eiaiafaha including a working party of nine men from Madilogo

3pm Excavation ends for the day. Field workers return for family duties and lotu held at 5pm

Informal interviews with village residents continued. LEAVESLEY records a number of surface finds collected by village residents

18th June

8am- Return to Eiaiafaha

KEAKO and PREBBLE collect DGPS readings for the site

3pm- Excavations at this site completed.

Informal interviews with village residents continued.

19th June

[1] (Ma i) Madilogo refers to the modern village, whereas the Old Madilogo village lies around 500 m to the North.

8am- Return to Eiaiafaha

KEAKO and PREBBLE collect DGPS readings for the site

3pm- Excavations at this site completed.

Informal interviews with village residents continued.

<u>20th June</u>

8am- Team departs for initial excavations at Ebologo including a working party of nine men from Ma i Madilogo. Jo lives at Ebologo and accommodated the team with use of his haus kuk

3pm Excavation ends for the day. Field workers return for family duties and lotu held at 5pm

Informal interviews with village residents continued.

<u>21st June</u>

SDA service day, no work permitted

Frank Rabi gave team permission to wash and dry excavated materials

Team consolidates notes

<u>22nd June</u>

8am- Team departs for Ebologo

4pm Some fieldworkers return to Ma i Madilogo for lotu, others stay to assist with completing the excavation. PREBBLE samples the excavation walls

5pm Excavations at this site completed.

Informal interviews with village residents continued.

<u>23rd June</u>

7am- Team and fieldworkers depart for the caldera of Madilogo Volcano

PREBBLE collects stone and sedimentary material for analysis (sourcing of tephra etc.)

9am- Team and fieldworkers continue on to the Dabonumu ridgeline site

Historic artefacts found on surface

1x1m excavation conducted

PREBBLE samples the excavation walls

4:30pm Team and fieldworkers return to Ma i

24th June

8am- Team departs for initial excavations at Eialogo including a working party of nine men from Ma i Madilogo.

3pm Excavation ends for the day.

25th June

8am- Team departs for initial excavations at Eialogo including a working party of nine men from Ma i Madilogo.

3pm Excavations at this site completed.

Informal interviews with village residents continued.

4pm Team packs up ready for departure

26th June

8am- Team ready for pickup by Pacific helicopter

11:30am- Pacific helicopter from Ma i Madilogo to Jackson's Airport. Clear conditions except for some cloud above Naoro.

12:30am LEAVESLEY and PREBBLE arrive at Holiday Inn and begin to prepare preliminary report. KUASO returns to NMAG to write out the export permit for the archaeological materials for further analysis.

ARCHAEOLOGICAL EXCAVATION

Site Selection

The selection of sites for archaeological excavation was based on a synthesis of oral histories collected during our 2012 field season, field observations (Prebble, Leavesley, Mandui and Kaitokai), and a GIS-based predictive modeling approach (Walker and Prebble) using archaeological and environmental parameters derived from existing archaeological records located within the Owen Stanley Range (namely at Kosipe, in the Ivane Valley and Kokoda – Leavesley and Prebble). In *Figure 1* a GIS model of a broad area of the Kokoda IPZ is presented demonstrating the marked influence that river proximity has on garden/clearing preferences, based on extracted satellite imagery data. Combining these data with a set of environmental parameters (including aspect, hydrological slope and land-use variables) pertaining to existing Pleistocene and Holocene archaeological sites in the Ivane Valley we can demonstrate the overall archaeological potential of Madilogo and vicinity and for Pleistocene archaeological potential (see *Figure 2*). The aim of this field season was to capture as much variation of site types as possible, to demonstrate and build a better model of archaeological potential for the region than has been afforded from existing records.

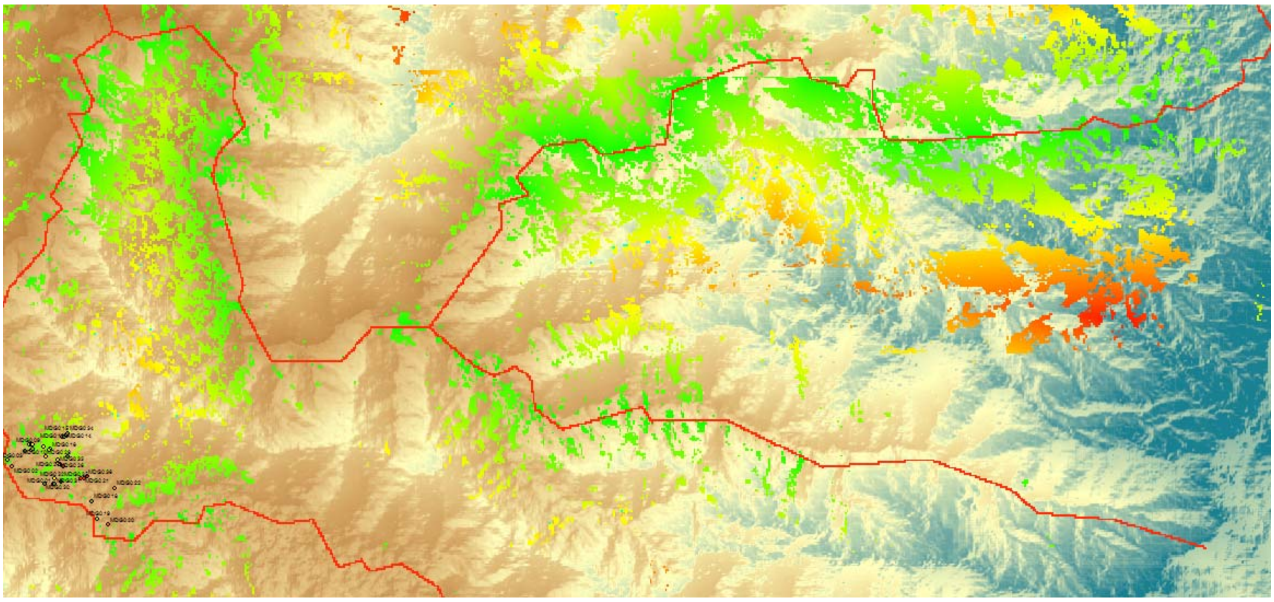


Figure 1. GIS analysis demonstrating the marked influence that river proximity has on garden/ clearing preferences with green areas being closest and red farthest away. Madilogo is shown by the collection of data-points in the bottom left of the image.

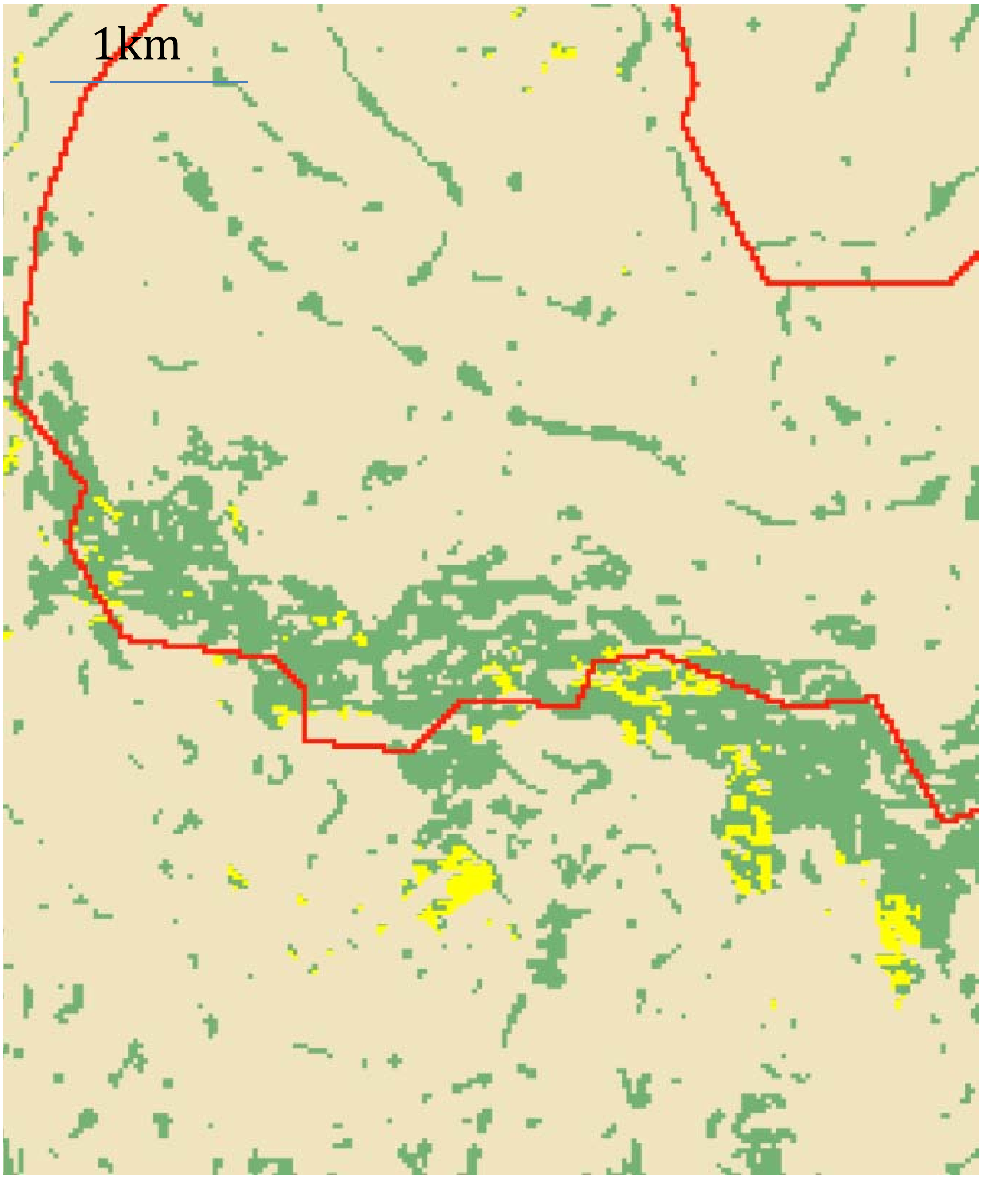


Figure 2. GIS analysis of the variables 'ASPECT','DISTANCE,'HYDROLOGICAL' SLOPE' and 'LAND'USE' demonstrating the overall archaeological potential of Madilogo and vicinity (Green) and for Pleistocene archaeological potential (Yellow). This model will be improved with the use of a high resolution DEM.

1. Eiaiafaha

Site Description
(NMAG site code yet to be obtained)

Eiaiafaha (E =water, Eiaia=river, faha=hole) is a promontory situated at 680 m in elevation and around 30m above a subterranean sink or aquifer, or possibly a lava tube in the Eiaia Creek (a tributary of the Naoro River). The sink lies around 50 m to the north of the site. Eiaiafaha is also located on the margins of the unoccupied and forest covered Tubelogo village, around 900 m northwest of Ma i Madilogo. The forest canopy consists of Okari (*Terminalia kaernbachii*) with an understory of *Ficus* spp., *Macaranga* sp., *Pouteria* sp., and *Artocarpus* sp., but dominated by the invasive small tree *Piper aduncum*. The site was chosen for excavation due to its proximity to the old villages of Tubelogo and Old Madilogo, both sites being last occupied in the 1950s (see Frontispiece).

Test Pit Excavation 2 x 2 m

The Test Pit surface is covered with Okari nut shells and pig 'routing' is noticeable in adjacent areas. The surface sediment consists of eroded scoria and decomposed organic materials and plant roots. The SW quadrant was excavated to 20 cm, and the NW quadrant to 50cm, while the NE and SE quads were excavated to 1 m. The spit depths, calculated for every 10 cm were meticulously coordinated across the entire 2 x 2 m excavation, with these excavation sampling methods applied to all other excavations presented in this report. The sediments consist of loose decayed scoria with the proportion of clay sediments increasing with depth. See the section drawing of the East wall of the excavation illustrating the predominant stratigraphy of the site (Figure 3).

EXCAVATION PROFILE: Eiaiafaha Test Pit 1 (2014), East Wall

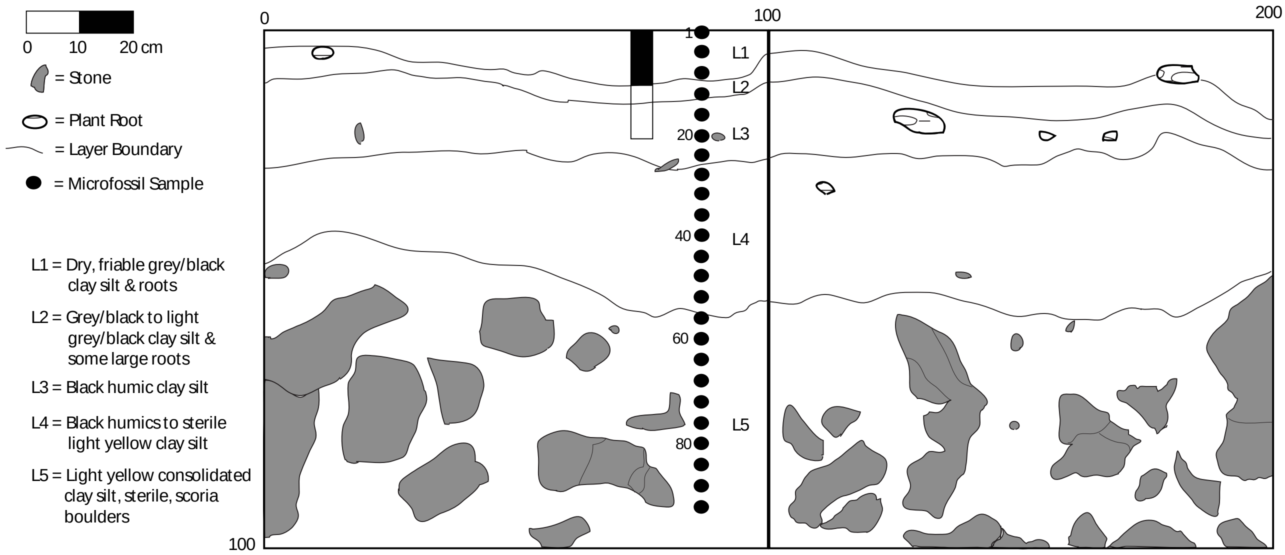


Figure 3. East Wall Profile of the Eiaiafaha Excavation

Artefacts

Fifty-one artefacts were collected from the top 90 cm of the site (see Table 1). They consist of uni-directional and bipolar cores, complete, broken and bipolar flakes. The artefacts were produced on a range of raw materials including; quartz, volcanics and chert. In particular, chert is relatively uncommon being present in two sites tested in the 2014 field season. The lower 10 cm of the deposit from 90-100cm in depth held no cultural material. The preliminary analysis presented here was undertaken by Harris and Leavesley in the Tropical Archaeology Research Laboratory at JCU in Cairns. Selected artefacts will later be analysed at the Department of Archaeology and Natural History (ANU) Laboratory for residue and use-wear-analyses to provide information on tool function.

Depth below surface (cm)	Artefact types	Material(s)	Broken or complete	#	Wt (g)
0-10	Complete flakes (4)	Quartz (4)	Complete (4)	4	2.18
10-20	Broken flakes (2) Core (1) Complete flakes (4)	Quartz (5) Volcanic (1) Chert (1)	Broken (2) Complete (5)	7	12.16
20-30	Broken flake (1) Core (1) Complete flakes (13)	Quartz (13) Volcanic (2)	Broken (1) Complete (14)	15	35.35
30-40	Broken flake (1) Complete flakes (9) Bipolar core (3) Bipolar flake (2)	Quartz (12) Volcanic (3)	Broken (1) Complete (14)	15	28.58
40-50	Broken flake (3) Complete flake (1) Bipolar flake (1)	Quartz (4) Volcanic (1)	Broken (2) Complete (3)	5	36.48
50-60	Complete flake	Volcanic	Complete	1	2.98
60-70	Complete flakes	Quartz (2) Volcanic (1)	Complete	3	1.49
70-80				0	0
80-90	Bipolar flake	Volcanic	Complete	1	0.35
90-100				0	0

Table 1. Summary of the Eiaiafaha stone artefact assemblage.

Microfossil Samples

Twenty-four sediment samples for pollen and phytolith analyses were taken from the East wall of the Southeast Quadrant of the 2 x 2 m excavation. These will be analysed in the coming months in the Department of Archaeology and Natural History (ANU) Laboratory

Wood charcoal samples

Large pieces of wood charcoal, where available, were collected from the sieved material for each spit. Some pieces have been submitted to the radiocarbon dating lab, Direct AMS (USA) to develop a chronology for the site. These pieces will later be analysed at the Department of Archaeology and Natural History (ANU) Laboratory and identified to species to provide information on fuel use in the vicinity of the site.

2. Ebologo

Site Description
(NMAG site code yet to be obtained)

Ebologo is a contemporary small hamlet consisting of a well-maintained large grass-covered clearing with five (5) houses (both new and unserviceable) situated on its periphery. The hamlet is situated around 1.5 hrs walk and 2 km SE (in a direct line) from Madilogo Village, on the southern side of the Naoro River. The hamlet, at an elevation of 815 m, is composed of four houses, but was the primary residence of only one family in June 2014. Ebologo lies on a North facing and sloped promontory separating two creeks to the NW and SE, respectively. The confluence of these creeks is situated at ~150 m below Ebologo to the north before draining into the Naoro River. The site has a northern aspect and is the only archaeological site investigated on the south side of the Naoro River. The surrounding forest canopy consists of okari (*Terminalia kaernbachii*) with an understory of *Hydriastele* sp., *Ficus* spp., *Macaranga* sp., *Pouteria* sp., *Artocarpus* sp. (breadfruit) and some *Pandanus conoideus* (marita), with surrounding fallow gardens dominated by extensive stands of the invasive pepper tree *Piper aduncum*. The site was chosen for excavation primarily based on our GIS modeling of Pleistocene and Holocene 'open' sites (see above), but also the historic 1957 imagery showing continuous active gardening since the 1950s (see Frontispiece). This imagery is unclear, but it appears that the hamlet was covered in forest in 1957, so has only been re-established as a hamlet since that time. These observations have yet to be confirmed from the local residents.

Test Pit Excavation 1 x 1 m

The Test Pit is located in the middle of the grass-covered flat. The four corners of the Test Pit were geographically positioned using a differential GPS (Hemisphere S320), providing an accuracy of <30cm resolution. The surface soil layer was around 5 cm in depth, with the sediment throughout the entire excavation dominated by yellow-brown clayey silt, with the proportion of clay sediments increasing with depth. Permineralised root nodules and pumice or decayed scoria stone were also more frequently encountered with increasing depth. A large amount of decayed scoria stone (identified by Prof. Hugh Davies UPNG) and a large amorphous piece of quartz was encountered at the base of the excavation (at 85 cm in depth). A post hole with an imbedded charred post was first identified at 5-6 cm below the ground surface and was excavated down to a depth of 85 cm. We ceased excavating the deposit at 105 cm below the ground surface, due to the absence of recovery of cultural material.

Artefacts

The Ebologo stone assemblage is dominated by quartz artefacts and has a relatively high number of bipolar cores (see Table 2). It also contains the only identified retouched flake and two artefacts classified as ground objects. This site also contains the only flake produced on sedimentary rock. A ground edge axe is produced by first flaking the given stone by direct percussion to the required pre-form shape and then painstakingly grinding the cutting edge smooth. While 'flaking', more accurately described as 'knapping' ordinarily produces fairly rapid results while grinding can be a relatively long and laborious process. Both knapping and grinding are evident in the Ebologo stone artefact assemblage. Aside from the post-hole charcoal deposit, the lower 55 cm of the deposit from 45-100 cm in depth held no cultural material. The preliminary analysis presented here was undertaken by Harris and Leavesley in the Tropical Archaeology Research Laboratory at JCU in Cairns. Selected artefacts will later be analysed at the Department of Archaeology and Natural History (ANU) Laboratory for residue and use-wear-analyses to provide information on tool function.

Depth below surface (cm)	Artefact types	Material(s)	Broken or complete	#	Wt (g)
0-5	Complete flake	Quartz	Complete	1	0.19
10-15	Broken flake (1) Complete flakes (15) Bipolar core (8) Retouched flake (1)	Quartz (22) Volcanic (2) Sedimentary (1)	Broken (1) Complete (24)	25	70.04
15-25	Complete flakes	Volcanic	Complete	2	6.36
25-35	Broken flake (1) Complete flakes (6) Bipolar core (1) Ground object (2)	Quartz (6) Volcanic (3) Chert (1)	Broken (1) Complete (9)	10	49.01
35-45	Broken flake	Quartz	Broken	1	0.53

Table 2. Summary of the Ebologo stone artefact assemblage.

Microfossil samples

Twenty sediment samples for pollen and phytolith analyses were taken from the South wall of the Southeast Quadrant of the 1 x 1 m excavation. These will be analysed in the coming months in the Department of Archaeology and Natural History (ANU) Laboratory

Wood charcoal samples

Large pieces of wood charcoal, where available, were collected from the sieved material for each spit. Some pieces have been submitted to the radiocarbon dating lab, Direct AMS (USA) to develop a chronology for the site. These remaining fragments will later be analysed at the Department of Archaeology and Natural History (ANU) Laboratory and identified to species to provide information on fuel use in the vicinity of the site.

3. Dabonumu

Site Description
(NMAG site code yet to be obtained)

Dabonumu is a hamlet or village last occupied in the 1950s or 60s based on oral histories and historical aerial imagery obtained for 1957 (see Frontispiece). Dabonumu sits at around 1110 m asl on a ridgeline that is currently completely forested. Although flat on the top, it is mostly narrower than 50 m across. Both sides of the ridge are extremely steep for almost the entirety of their 240 m descent into the valley floor on either side. The only reasonable access is a track along the ridge-top to the east or via a relatively less steep spur to the Madilogo vicinity to the south west. Oral histories suggest that this site was the location of the founding ancestral village of the valley and was occupied before the advent of SDA missionary contact in the region, in the early 20th Century. The site is currently covered in forest, with the surrounding canopy consisting of *Pandanus* sp, *Cyathea* sp., *Hydriastele* sp. and Meliaceae sp. with an understory of *Cordyline fruticosa*, *Calamus* sp. and abundant ground ferns (*Sticherus* sp., *Blechnum* sp. and *Asplenium* sp.). The site was chosen for excavation due to the significant oral history of the site, but also the aerial imagery indicating that the site had been extensively cleared in the past (see Frontispiece). Demonstrating the archaeological potential of such a remote location, at 2.5 hours walk but only 2 km from Ma-i Madilogo, was a driving factor behind our excavation strategy. Prior to excavation a series of surface objects were identified including a former house post and an old metal bucket. Our local informants, represented by Frank Rabi, agreed these objects reflect the most recent occupation of the site. See Prebble et al. (2013) for a broader description of the ethnography associated with this site.

Test Pit Excavation 1 x 1 m

The test pit was placed on a relatively central and flat area around 10 m below the highest point on the ridgeline that appeared to represent a sediment depositional center. The first 0-5 cm of the excavation was removed due to the presence of large roots. This excavation compared to other sites examined in the rest of the valley can be characterized by the lack of decayed scoria. The base of the deposit at a depth of 105 cm overlies some heavily degraded stone, but much of the deposit is composed of fine dark brown, brown or reddish-brown clayey silt.

Artefacts

Six artefacts were collected from the top 75 cm of this site (see *Table 3*). The most remarkable is the obsidian flake from between 30-35 cm below the ground surface. The nearest obsidian source to the Naoro Valley is on West Fergusson Island in Milne Bay. The most parsimonious explanation for its presence in this site is that it was exchanged 'down-the-line', hand to hand from community to community before it was ultimately incorporated into the Dabonumu deposit. Also notable was the presence of a flaked grass marble of the type children across New Guinea use for games. The remaining flakes were produced on quartz which is locally ubiquitous. The assemblage includes evidence of both direct and bipolar percussion. The preliminary analysis presented here was undertaken by Harris and Leavesley in the Tropical Archaeology Research Laboratory at JCU in Cairns Selected artefacts will later be analysed at the Department of Archaeology and Natural History (ANU) Laboratory for residue and use-wear-analyses to provide information on tool function. The obsidian flake will be examined for its elemental composition by Prof. Glenn Summerhayes (University of Otago), to confirm the visual similarity with West Fergusson sources.

Depth below surface (cm)	Artefact Type	Material	Broken or Complete	Wt. (g)
5 – 15	Complete Flake from glass marble	Glass	Complete	0.31
25 – 35	Bipolar Core	Quartz	Complete	2.05
30 – 35	Complete Flake	Obsidian	Complete	0.07
35 – 45	Complete Flake	Quartz	Complete	1.5
45 – 55	Complete Flake	Quartz	Complete	0.78
65 – 75	Broken Flake	Quartz	Broken	0.15

Table 3. Summary of the Dabonumu stone artefact assemblage.

Microfossil Samples

Twenty sediment samples for pollen and phytolith analyses were taken from the South wall of the Southeast Quadrant of the 1 x 1 m excavation. These will be analysed in the coming months in the Department of Archaeology and Natural History (ANU) Laboratory.

Wood charcoal samples

Large pieces of wood charcoal, where available, were collected from the sieved material for each spit. Some pieces have been submitted to the radiocarbon dating lab, Direct AMS (USA) to develop a chronology for the site. These pieces will later be analysed at the Department of Archaeology and Natural History (ANU) Laboratory and identified to species to provide information on fuel use in the vicinity of the site.

4. Eialogo

Site Description
(NMAG site code yet to be obtained)

Eialogo is a presently unoccupied village located at 740 m asl and 10 m above the Eia Creek that lies around 100 m to the north. This site is located upstream from Eiaiafaha. The local ethnography suggests that upon contact with the SDA Missionaries the villages at Dabonumu and other locations moved to Eialogo. In 2012, team members led by Prebble collected augered sediment samples from this site. The test pit was situated adjacent to the auger hole. The excavation site is located on the margins of the old village complex. The forest canopy consists of Okari (*Terminalia kaernbachii*) with an understory of *Ficus* spp., *Macaranga*, *Pouteria*, and *Artocarpus,* but dominated by the invasive small tree *Piper aduncum*. The site was chosen for excavation due to its proximity to the old village, but the primary driver behind this site selection is the results of the microfossil and sedimentary record indicating 2800 years of forest clearance activity and gardening (see Appendix 2 for a summary of these results). This village complex also forms part of the oral history of village mobility in the time before missionary arrival. The village was occupied after the abandonment of Dabonumu, but was abandoned when people moved to old Madilogo then finally Ma-i Madilogo.

Test Pit Excavation 2 x 2 m

The test pit surface was covered with ferns which were cleared before excavation. The top humic sediment between 0 and 25 cm consisted of abundant plant roots. The fine sediments of this deposit consist of loose decayed scoria with the proportion of clay sediments increasing with depth. The amount of ‘natural’ non-artefact stone present within each 10 cm spit is greatest between 75 to 85 cm. Two large blocks were located between 55 and 65 cm, one of which appears to have a concavity (facing upwards in the deposit), which is reminiscent of a cupule from an anvil stone. It may be natural as it lacks the kind of morphological regularity common to crafted anvil stones. However, many contemporary anvil stones found in the vicinity of the site (see Prebble et al 2013 and below) are often irregular in shape. See the section drawing of the South wall of the excavation illustrating the predominant stratigraphy of the site (*Figure 4*). Also see Appendix 2 for further sediment descriptions base on the auger sediments collected from Eialogo in 2012.

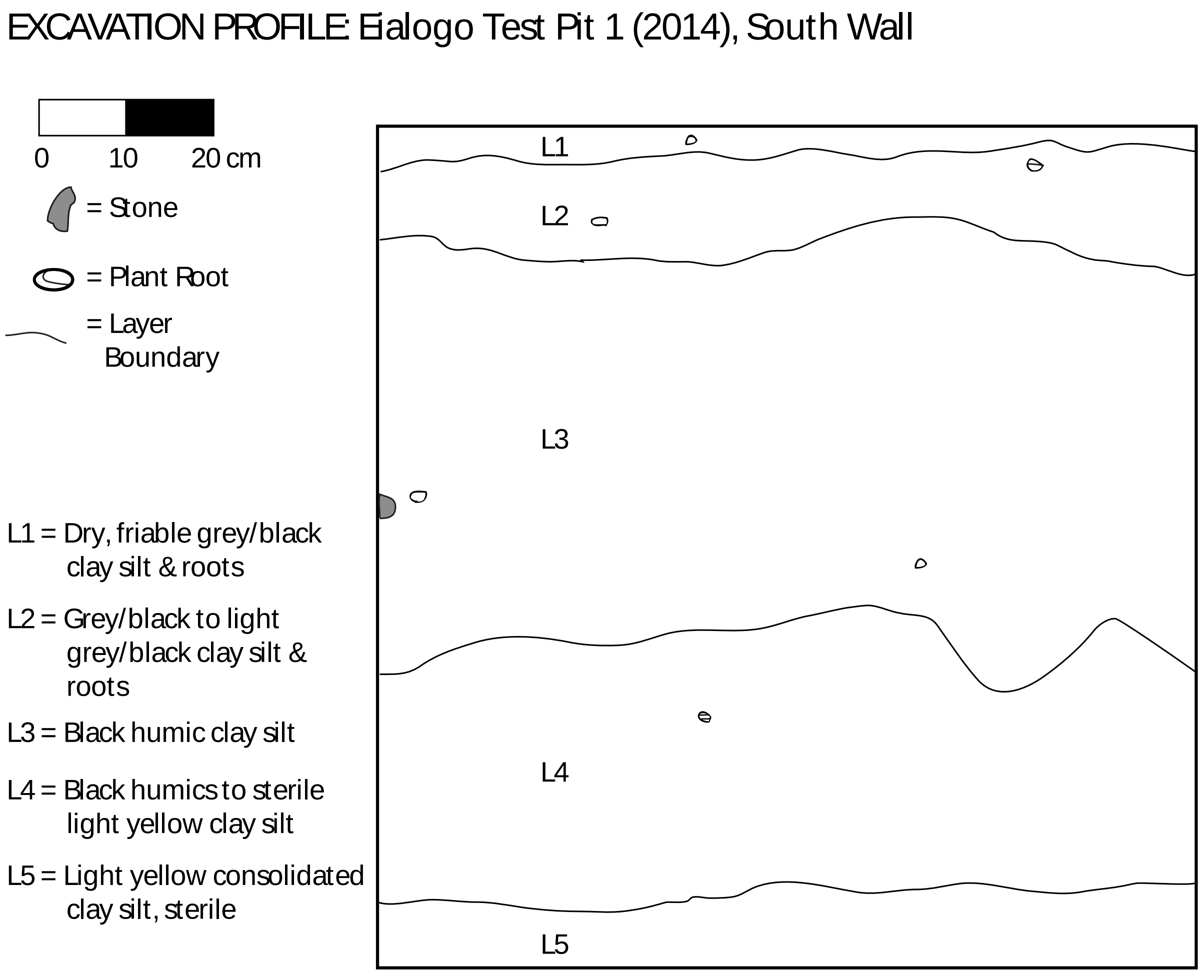


Figure 4. South Wall Profile of the Eialogo Excavation

Artefacts

The Eialogo stone artefact assemblage (see *Table 4*) contains a complete edge ground stone axe (see *Figure 5*) and a blade fragment of a second edge ground stone axe. It also contains one of only two obsidian flakes (see *Figure 6*) so far recorded in the lower elevation areas of the lower-montane Naoro Valley. By comparison with the auger (see Appendix 2) these artefacts date to between 2800 and 2500 years ago. The preliminary analysis presented here was undertaken by Harris and Leavesley in the Tropical Archaeology Research Laboratory at JCU in Cairns. Selected artefacts will later be analysed at the Department of Archaeology and Natural History (ANU) Laboratory for residue and use-wear-analyses to provide information on tool function. The obsidian flake will be examined for its elemental composition by Prof. Glenn Summerhayes (University of Otago), to confirm the visual similarity with West Fergusson sources.

Depth below surface (cm)	Artefact types	Material(s)	Broken or complete	#	Wt (g)
0-5				0	0
10-15				0	0
15-25				0	0
25-35	Broken flakes	Quartz	Broken	2	0.32
35-45				0	0
45-55				0	0
55-65	Broken flake	Quartz	Broken	1	0.81
60-65	Complete flakes (2) Ground edge axe fragment (1)	Volcanic (2) Obsidian (1)(Figure 4)	Broken (2) Complete (1)	3	13.3
65-70	Ground edge axe (Figure 3)	Volcanic	Complete	1	46.81
70-75				0	0
75-85	Broken flake	Volcanic	Broken	1	1.89
85-95	Broken flake Complete flake	Quartz Volcanic	Broken (1) Complete (1)	2	0.2

Table 4. Summary of the Eialogo stone artefact assemblage.

Microfossil Samples

Twenty-four sediment samples for pollen and phytolith analyses were taken from the East wall of the Southeast Quadrant of the 1 x 1 m excavation. These will be analysed in the coming months in the Department of Archaeology and Natural History (ANU) Laboratory

Wood charcoal samples

Large pieces of wood charcoal, where available, were collected from the sieved material for each spit. Some pieces have been submitted to the radiocarbon dating lab, Direct AMS (USA) to develop a chronology for the site. These pieces will later be analysed at the Department of Archaeology and Natural History (ANU) Laboratory and identified to species to provide information on fuel use in the vicinity of the site.

SUMMARY OF ARTEFACT ASSEMBLAGES

The assemblages from Eiaiafaha, Ebologo, Dabonumu and Eialogo indicate that the middle Naoro River basin region within proximity of the former village of Madilogo has an extensive archaeological record (see Appendix 1 for complete table of the analyses conducted by Clair Harris and Matthew Leavesley). While only one site has yet been radio-metrically dated we know that humans began using the region at least by 2900 years ago. They utilised both direct percussion and bipolar percussion techniques and edge ground blade production technology. They used the locally ubiquitous quartz and volcanics as well as smaller quantities of sedimentary rocks, chert and obsidian. They also participated in an exchange system that extends at least as far as West Fergusson Island. The 106 stone artefacts recorded from the Madilogo excavations have a density of 26.5/m^3. Comparable artefact densities for Holocene open sites in Papua New Guinea are rare. The Kafiavana rockshelter site has 163/m3 (White 1972) which is typical of rockshelter deposits, but Epe Amoho shelter in Gulf Province has less than the Madilogo assemblages at only 20/m^3 (McNiven et al 2010). It remains to be seen how these assemblages compare with recently excavated assemblages at Caution Bay (David et al. 2011).

Figure 5 Small ground stone axe from Eialogo Test Pit 1. (Scale 2 cm)

Figure 6 Obsidian flake, Eialogo Test Pit 1. Characteristic of West Fergusson material. (Scale 1 cm)

OBSIDIAN EXCHANGE IN THE NAORO VALLEY

The location of obsidian flakes, characteristic of the West Fergusson sources (yet to be quantified), from the Naoro Valley excavations is one of the most significant aspects of our research to date. As we outline below, obsidian exchange is a key component of Pleistocene and Holocene economies and exchange systems in Papua New Guinea and these finds dating to 2800 years ago, connecting the Naoro Valley with a particularly stone source that was exchanged as far as Vanuatu right through to Indonesia.

Inter-island exchange of obsidian in New Guinea occurred in the Pleistocene and was focused on New Britain sources (Summerhayes 2009). It was not until the arrival of Lapita that this formerly local exchange system rapidly extended across around 3000 km of ocean to encompass Fiji and Borneo (Summerhayes 2009). The westward extent of obsidian exchange, from the main quarries of West New Britain (Talasea or Kutau/Bao), is marked by the 3000-2000 year old deposits in the Bukit Tengkorak shelter in Sabah (Bellwood 1989, Chia 2003, Reepmeyer et al 2011). This obsidian has also been identified from surface finds from Cebu at Lastimoso in the Philippines (Reepmeyer et al 2011). Until recently the earliest reported exchange of obsidian along the Papuan Peninsula coast was thought to be concurrent with the appearance of what was formally known as Early Papuan Pottery (EPP) 2500 years ago. Obsidian trade was assumed to have been restricted to the north coast of New Guinea, but recent excavations from the Caution Bay Lapita site, near Port Moresby have changed this view. Obsidian from the Igaweta and Fagalulu sources on West Fergusson Island in the D'Entrecasteaux group was identified (McNiven et al 2011), albeit not from the Kutau/Bao sources, but this still confirms the existence of a southern exchange route. West Fergusson obsidian may have formed part of a Lapita exchange system, nevertheless it has been identified as far west as the Moluccas and as far east as the Santa Cruz Group, Solomon Islands (Green and Bird 1989) and Teouma, Vanuatu (Reepmeyer et al 2010). It has also been identified on the Sepik coast at Tumleo (Golitko et al 2012) and now in the Naoro Valley.

Of note are the four West New Britain obsidian flakes excavated from the Eastern Highlands site of Kafiavana (White 1972: 98, 109). These were excavated from Horizons I and II which in our opinion appear to be part of Phase III (the upper 50 cm of the deposit) which dates to post-2000 years ago. Summerhayes (2009) interpreted these pieces to be within the Phase II deposits, dated to 4500 years ago, but due to the disturbed upper deposits of this site we suggest a more conservative chronological interpretation. The obsidian flakes from both Kafiavana and Naoro Valley are all small, with minimal cortex and reveal only minor artefact production at the site. This suggests that these flakes were worked before importation, and may represent a form of non-economic or symbolic utilization (Sheppard 1993). This may be a function of the lack of sampling resolution, which could be resolved with more excavation, as the exchange of larger pieces of obsidian (e.g. cores) or pre-worked pieces would represent more complex economic utilization.

An interesting aspect of the Naoro Valley obsidian flakes is that they are located in both the valley flats at Eialogo and on the ridgeline site of Dabonumu at 1100 m. The function of obsidian tools on a ridgeline site would perhaps afford less opportunity for any economic utilization, and instead probably served as a symbol of connectivity for the ridgeline occupants with the newly established coastal exchange network. Within our recommendations (see below) we suggest that excavations of sites, both in the upper reaches of the Naoro Valley (e.g. at Manari) and in the valleys at higher elevations (e.g. Myola), should be conducted to determine the extent of this exchange network. Although we think unlikely, it is still possible that the direction of the obsidian exchange could have been from the north and further excavations should be conducted in the northern periphery of the IPZ.

SURFACE FINDS

Nut-cracking stone anvils

Okari and other nuts are an important protein source throughout the Mountain Koiari region (see below). Past and present inhabitants of the region use either an axe or hammer stone in combination with an anvil stone to break the outer nut shell in order to gain access to the nut itself. Nut cracking anvils were identified at ten different locations in our 2012 study (Prebble et al 2013). Many more were identified in the June 2014 season, but were not recorded given their apparent abundance and are suggested as a priority for future field research. Our observations of anvil stones supports the hypothesis that they may have been associated with either former village sites or the nut trees themselves.

Other stone tools

Prior to the introduction of steel, stone was the main material sourced for the production of tools. They provide archaeologists with important clues into past human activities related to their implicit technology and function. Surface artefact finds inform archaeologists about notions of landscape use. Six **s**tone objects were identified by the team during the 2012 survey (MDG00A, MDG00B, MDG00C, MDG00D**,** MDG00E and MDG00F). These include four stone axe blades, either of Late Pleistocene or Holocene age, and a mokmok (MDG00F), an East New Britain term for a stone disc with a perforation[2].

[2] These were apparently used as stone currency or for decoration, tied on a belt of a chief, but other functional uses of these types of stone may also include fibre production as an early form of spindle whorl for processing vine fibres. Similar discs have been located in Late Pleistocene sites in Southern China (Judith Cameron pers. comm.). Another alternative is that these served as a stone weight on early digging sticks as found in many stone tool assemblages in different parts of Africa (e.g. Davies, 1967)**.** In the 2014 season another three stone axe blades (MDG00H, MDG00I and MDG00J) were recorded as well as another mokmok (MDG00K).

ENVIRONMENTAL ARCHAEOLOGY

In 2012, we augered a series ~1 m deep sediment deposits in the vicinity of the contemporary and old villages on what we call the 'Madilogo Flat'. One auger site (MDG034) at the ancestral village of Eialogo, was originally interpreted to potentially hold the original Pleistocene-aged 'Kosipe Type' black soil or Holocene black soils (Prebble et al 2013). Our excavations at this site now show that this is an important cultural deposit and microfossil and radiocarbon analyses (Appendix 2) now show that this is less than 3000 years old, confirming our later Holocene black soil interpretation. This is an important result, considering the presence of obsidian and chert and the ramifications for the presence of these exotic tools as evidence of exchange with coastal communities. Other sediment deposits augered in 2012 on the Madilogo Flat revealed highly weathered sediments preserving little organic material (Prebble et al 2013). Based on the archaeological findings in the June 2014 season combined with the microfossil analyses (see Appendix 2), we now suggest that the other augered deposits examined in the 2012 season (MDG031, MDG032, MDG033, MDG035 and MDG036) do not represent large village complexes, but may have served some other function in the landscape including as gardens, as was the case with Kabi's Garden (MDG035 and MDG036).

The auger profile (MDG034) from Eialogo has been examined for fossil pollen, phytoliths and charcoal particles and other environmental proxies including radiocarbon dating, in order to establish the age and background vegetation change and cultural sequence (see Appendix 2). Our provisional synthesis of these data combined with our excavation data from Eialogo suggests that at around 2800 years ago, there was a rapid expansion of village settlements, forest clearance and the influx of *Terminalia* microfossils indicative of okari aboriculture.

Volcanism in the Naoro Valley

Lying at an elevation of around 850m, and around 250m above and 1 hour walk from the contemporary Ma-i Madilogo village, lies the strombolian Madilogo volcano (Blake 1976). Due to the extensive forest cover of the region and the general inaccessibility of the caldera it was not recognised until 1969 and consequently has been poorly described (Blake, 1976). The volcano produced a lava flow that extends 1km to the west of Ma-i Madilogo and probably dissected the Naoro River to form the Kaiavu waterfall. Although an eruption record does not exist for the site, it seems certain that the volcano is responsible for ash/tephra fall events over the village site of at least some time in the past and more likely on multiple occasions. Attempts by Blake (1976) to loosely reconstruct the age of the main lava flows, based upon re-vegetation rates, place it at less than 1000 years old or even a few hundred years old. Our excavations conflict with this interpretation, as the basal deposits from the Madilogo Flat sites (Eialogo and Eiaiafaha), which we have radiocarbon dated to around 2800 years, overly a dense base of decomposed scoria indicative of a lava flow.

The Ebologo archaeological deposit, situated 2 km south from the Madilogo Volcanoe caldera, on the southern side of the Naoro River, overlies isolated boulders of highly degraded scoria which we suggest may have been deposited as fragmental ejecta. The Ebologo scoria, from a provisional analysis is less dense than the material excavated from Madilogo Flat. We assume that this deposit is of a similar age to the Madilogo Flat deposits, but the forthcoming radiocarbon dates on archaeological charcoal will provide a minimum chronology for scoria deposition. The base of the Dabonumu deposit on the ridgeline above Madilogo Flat and the caldera consists of what we assume to be older basaltic stone, but not decayed scoria from the eruption that affected the other sites, again attesting to the localized lava flows and ejecta.

It is still conceivable that the analysis of Blake (1976) was partly correct as tephra may have been deposited in small eruptive phases over the last 1000 years. Such events may have been minor as tephra sourced to this volcano has yet to be located in lake or swamp deposits in proximity to the caldera. The impact of Mt Lamington, 70km to the NE of Madilogo Flat, is better established with deposits recorded from a several locations back to approximately 70,000 yrs BP and most recently in 1952 (Ruxton 1988; Coulter 2009).

The implications of the volcano for the archaeology of the Naoro Valley are twofold. Firstly, there is a minimum time before occupation of the valley was possible as the lava flows and ejecta would have temporarily decimated the valley. It is possible that the main lava flow occurred not long before initial occupation 3000 years ago. Secondly, there is some data from other volcanic zones that tephra laden substrates of intermediate age (hundreds of years) are more fertile than very young (<100 years) or very old substrates (thousands of years; Hartshorn et al. 2006). Ash-rich soils also have a greater surface area and water holding capacity (Chadwick et al. 2003). The microfossil data, particularly of spikes in Cyperaceae sedge pollen, from the MDG034 auger show that there were periods when Eialogo was not free draining. From our analysis of tephra sherds from within these sediments we suggest that the frequent eruptions either from Madilogo Volcano or other eruption sources, was followed by periods of water logging and the formation of small wetlands. The main tephra spikes occur before 1300 BC, between 800 BC and AD 900, and at ~AD 1500 and ~AD 1700. After these periods we can hypothesise that Eialogo became more suitable for the establishment of agriculture and for village expansion.

The significant body of research conducted in East New Britain (e.g. Torrence et al 2012) provides a useful model for further research within the IPZ in highlighting the importance of active volcanic areas to human populations. The archaeological and environmental data obtained from the Willaumez Peninsula excavations show that people may have taken advantage of the effects of volcanic activity to establish relatively permanent gardens and therefore avoid the costs associated with shifting cultivation. To establish whether the Willaumez Peninsula model applies to the Naoro Valley, particularly those areas in proximity to Madilogo Volcano needs to be tested. It is possible that the Naoro Valley is unusual and because of the fertile soils associated with the intermediate-aged Madilogo Volcano lava flows may have drawn populations of people to this valley, more so than less fertile adjacent valleys.

Comparative records of environmental change

We have previously provided a summary of comparative studies indicating environmental changes across the Papuan Peninsula (Prebble et al 2013). The most useful study for comparison with the Eialogo sequence, comes from Touku, 20 km to the east of Kokoda Station, Oro Province (Hope and Prebble in prep). Fossil pollen and charcoal particle data suggests that some degree of human influence has been present for at least 6000 years in the Yodda valley. This sequence partially resembles the Highland valleys of the Western Ranges of Papua New Guinea and which were substantially disturbed by around this time (Hope and Haberle 2005). Transformation of the lower slopes of the surrounding mountains is now obvious, and the Naoro Valley and Madilogo Valley Flat has been intensively managed for arboricultural and agricultural production long before the European era introduction of new crops, animals, and plantation techniques. The record from Touku suggests that large scale village settlements extend back to around 3000 years ago with earlier less intensive occupation indicated by at least 5500 years ago. This evidence for a later expansion of village settlements runs in direct parallel with the Eialogo sequence.

The effects of large tephra falls on settlement patterns have been studied in New Britain at Yombon at ca 500m altitude where Torrence et al (2012) have identified on a long sequence of abandonment and resettlement after large tephra events. They found evidence for arboriculture and horticulture from the early Holocene and also used the occurrence of charcoal particles to infer anthropogenic burning from late Pleistocene times. They also indicate a parallel between their records and the Highlands. Regular falls of volcanic ash may have buried living forest floors, as occurred in the Pleistocene in the Ivane Valley (Summerhayes et al 2010). It seems unlikely that tephra falls in the Yodda Valley in the past would have had lethal effects on vegetation or people as they probably represented weeks or months of ash fall. Though probably socially disruptive, the record from Touku provides tentative evidence that after large eruptions the tephra (often washed downslope) may have changed local soil hydrology and nutrients. These new soils may have also been a useful resource for developing new gardens and arboricultural systems (Hope and Prebble in prep). The Touku record suggests that lowland and inland valleys may have presented attractive sites for agriculture and crop development over the long-term.

Within the last 5000 years two key volcanic ashfall events have been recorded at Touku including:

1. 4,000 years ago, possibly a major Mt Lamington ashfall event;
2. 500 years ago, a likely Mt Lamington event;
3. 300 years ago, possibly the Tibito (Long Island) eruption event, recorded throughout many parts of the Highlands and other parts of Papua New Guinea (Coulter et al 2009).

Another comparative environmental archive of relevance for the Eialogo record comes from Lake Waigani, within the Laloki catchment (Osborne et al 1993; Finn et al., in prep). Fossil diatoms and charcoal particle data from lake sediments radiocarbon dated to 3500 years ago reveal a number of peak sedimentation events. These events may be indicative of higher precipitation, vegetation clearance, or possibly volcanic ash deposition although, no distinct bands of tephra have been identified within the MDG034 record. These data suggest humans had some influence on the site within the last 3000 years, but the environmental impacts were minimal. The earliest peaks in charcoal particles found in Lake Waigani are synchronous with the evidence for Lapita arrival in the Port Moresby/Caution Bay area (McNiven et al 2011).

The main events are recorded as follows:

1. 2800 to 2500 years ago impacts of increased human inhabitation
2. 2500 to 1600 years ago, reduced human activity
3. 1600 to 1200 years ago increased human activity

4. 1000 years ago to the present reduced precipitation but with sustained forest burning.

Further characterization of the environmental events represented at Touku and Lake Waigani and other sites is required, but similar changes are represented within the Eiologo sequence (see Appendix 2).

Implications of the MDG034 Eialogo record

Based on the microfossil examination of the Eialogo sequence (Appendix 2) we conclude the following:

1. Prior to 3000 years ago (1700 to 1000 BC) little organic accumulation and microfossil preservation is recorded at the site and the vegetation consisted of tall rainforest tree species including *Elaeocarpus*. Low charcoal concentrations may indicate less forest modification

2. From 3000 to 2800 years ago (1000 to 800 BC) there is a transition from arboreal to grass dominance towards indicating a more open, non-forest environment. Cyperaceae sedges are found in their greatest abundance in this period and may indicate waterlogged soils from reduced drainage from volcanic ash deposition. The presence of abundant *Pseudoschizaea* resting spores indicative of seasonally exposed soils. The increase in magnitude of burning events suggests forest clearance, potentially for the expansion of village and garden sites. *Terminalia* pollen and possible phytoliths (probably of Okari) are most strongly represented in this part of the record and indicate possible arboriculture at this time.

3. From 2800 to 1200 years ago (800 BC to AD 800), there is a hiatus in the record, possible due to site abandonment, changing climatic conditions or volcanic tephra deposition.

4. From 1200 to 600 years ago (AD 800 to 1400), Grasses are abundant but decrease towards the top as palms and Urticaceae/ Moraceae increase. Trees and shrubs remain consistent throughout this period but have a comparatively low presence. *Pseudoschizaea* resting spores indicate an open environment that is seasonally dry.

5. From 600 years ago to the present (AD 1400 to the present), a mixed mosaic of vegetation types are presented in this period. Grasses are common, and of the trees present, palms dominate. It is possible that the region wide volcanic ash-fall events including from Mt Lamington at around 500 years ago and Tibito at around 300 years ago are represented in this record, but the responses of vegetation are unclear.

The significance of the Okari nut (Terminalia kaernbachii Warb. Combretaceae)

> August 1st 1879 *'I stayed with a party of natives who were getting a kind of large almond with a thick fleshy rind, the nut inside very hard, which they broke open with stones, filling their kits with kernels. They call the nut okari. They fed me with sugar-cane, taro, and okari, and then got leaves for me to rest on.'* Rev James Chalmers (in Chalmers 1886: 111) earliest reference to okari nuts, confirming its pre-European contact status within the central Goldie River catchment at 720 m in elevation

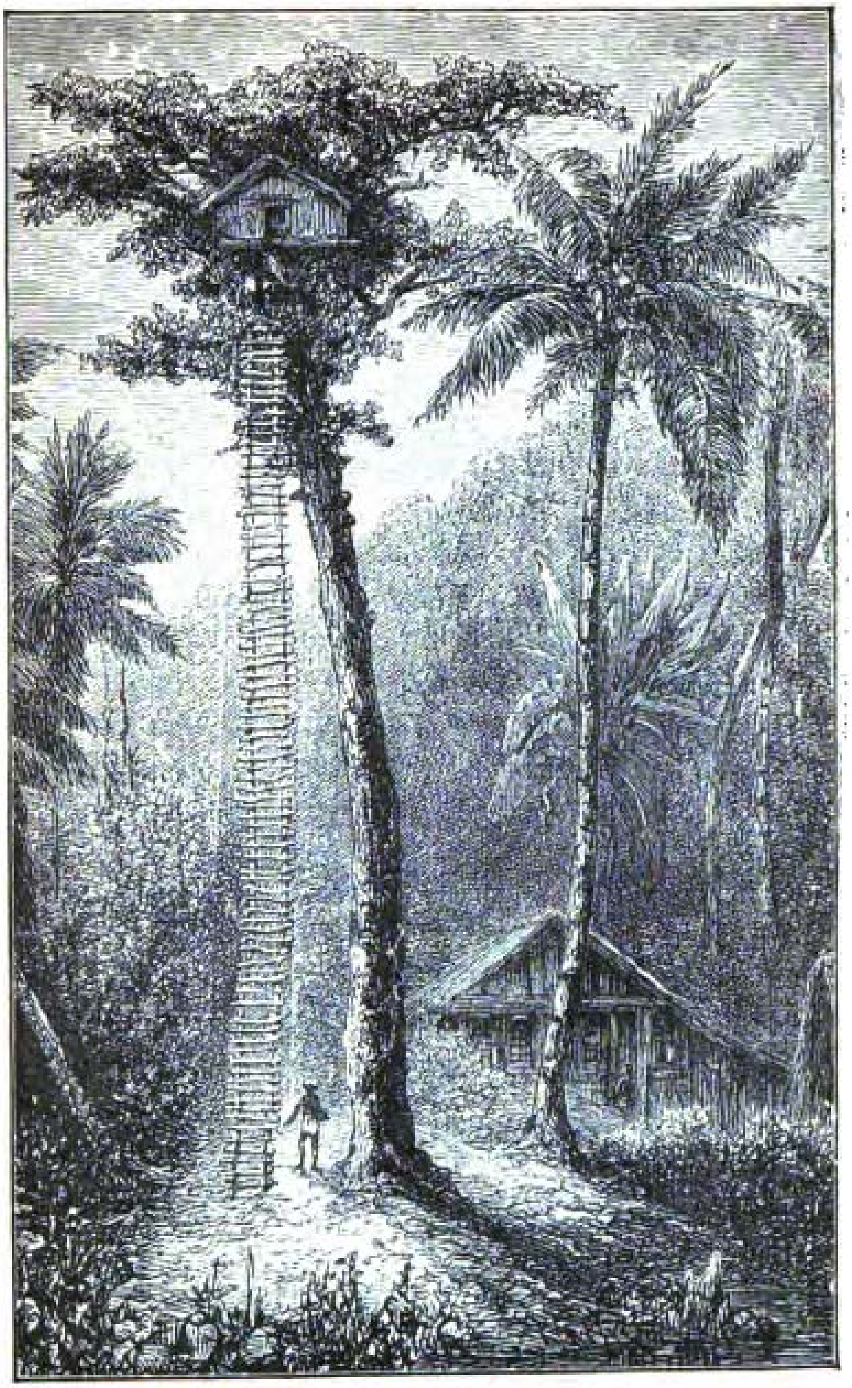


Figure 7. Chalmers 1886: 101 showing a hamlet at 720 m in elevation in the upper catchment of the Goldie River in 1879. Illustrated is a tree house within what appears to be an okari tree (*Terminalia kaernbachii*) with a coconut (*Cocos nucifera*) alongside. The presence of coconut indicates a strong coastal connection, as these trees, like the okari, must have been translocated into the lower montane zone.

Rich in fat and protein, many nut kernels, such as those of the okari, provide significant nutritional value. In addition to their high proportion of plant fats, nuts supply large quantities of the essential fatty acids, linoleic acid and linolenic acid, which the human body cannot produce on its own (Mathews et al 2000). The importance of nuts to montane Papua New Guinean societies has probably been down-played when compared to the importance of animal hunting. Part of this is due to the preservation and site selection bias of archaeological records in these montane regions. Much of the research, to date, has been based on rockshelter deposits, holding unique deposits, often rich in animal bone and lacking plant remains. By contrast open site excavations, like those conducted in the Naoro Valley, have been the most archaeologically informative for understanding the timing of human occupation of New Guinea and Pleistocene nut-based (karuka *Pandanus juilianetii*/*brosimos* complex) subsistence (Summerhayes et al 2010); and understanding the timing and independent development of complex plant production systems in the early to mid-Holocene (Denham et al 2003, Denham and Barton 2006). We contend, as other authors have done that plant products, particularly nuts, probably formed a more pivotal part of the adaptive subsistence strategies in montane Papua New Guinea than hunting.

Madilogo lies within the lower montane forest zone between c. 700 to 1500 m, characterized by dominant tall evergreen forest trees including *Castanopsis* and *Elaeocarpus* spp. (Mabbutt et al 1965, Paijmans, 1976). The sub-canopy is often composed of *Pometia*, *Artocarpus*, *Sterculia* and *Pandanus* spp. growing in acid red or brown clay soils and acid brown lithisols (Mabbutt et al 1965, Paijmans, 1976). Lower montane forests may have naturally provided a variety of edible seed and nut producing plants for immediate consumption (e.g. *Castanopsis* spp., *Pandanus conoideus*, *Gnetum gnemon*, *Pometia pinnata*) and storage (e.g. *Pangium edule*) forming a central part of the diet of 'hunter-gatherer' societies (Mountain 1991, Yen 1991). However, the origin of more intensive modes of production, including arboriculture and agriculture that may have arisen with population expansion in the Holocene, remains contentious. The long-term centrality of okari (*Terminalia kaernbachii*) in the production systems of the Mountain Koiari who live in the lower montane forest zone (Prebble et al 2013) is emphasized by the early description of Rev. James Chalmers (see above). Here we briefly explore aspects of okari domestication and arboriculture based on its biological traits (see Prebble et al 2013) and microfossil representation within the Eialogo archaeological sequence.

Yen (1982) first suggested that plant domestication in Papua New Guinea could have started in the lower montane forest and lowland forest zones as many of the most of the important 'domesticated' plants have their origins in these vegetation zones. Yen (1991) later presented the 'extension of adaptation' hypothesis of lowland and coastal species as well has highland and highland fringe species. He cites *Terminalia copelandii*, probably synonymous with *T. kaernbachii*, as one of the few trees of probable lowland/coastal origin that has been specifically adapted for production in lower montane and lowland forests. The 'wild' distribution of okari is unknown (see Figure 8 for a map of herbarium specimens of okari known from Papua New Guinea), but due to its semi-deciduous habit, losing some of its leaves during the dry season, it is likely that this tree was originally found in highly seasonal deciduous forest belts found lowland/coastal areas of southern New Guinea. A belt of slightly deciduous forest (see Figure 9) is present inland from the south-central coast indicating a transition between savannah (annual rainfall <1.25 m) and evergreen rainforest (annual rainfall >2.5 m). These slightly deciduous forest belts probably formed due to a combination of seasonal drought stress and shallow soils. Deciduous trees frequently found within these forests include *Garuga floribunda*, *Brachychiton carruthersii*, *Intsia bijuga*, *Protium macgregorii* and *Sterculia* spp. Numerous *Terminalia* spp. and other Combretaceae (e.g. *Combretum*) are also found within this slightly deciduous forest belt, many of which have complex cytologies, indicative of potential selective pressure by humans. A strongly deciduous forest pocket is found on the coastal limestone hills near Port Moresby where the annual rainfall is less than 1 m (*Figure 9*). Other species, in addition to those above, are *Gyrocarpus americanus*, *Bombax ceiba*, *Albizia* spp., *Maniltoa* spp., *Adenanthera pavonina* and *Erythrina* spp. This forest has a low and open canopy and in places grades into woodlands. Less *Terminalia* spp. are found in this forest type.

Figure 8. Google Earth image with the locations of recorded herbarium specimens of okari (*Terminalia kaernbachii*). Note the main collections are known from lowland rainforest zones of the Papuan Peninsula. Most records are derived from the PNG Plants database (http://www.pngplants.org/PNGdatabase).

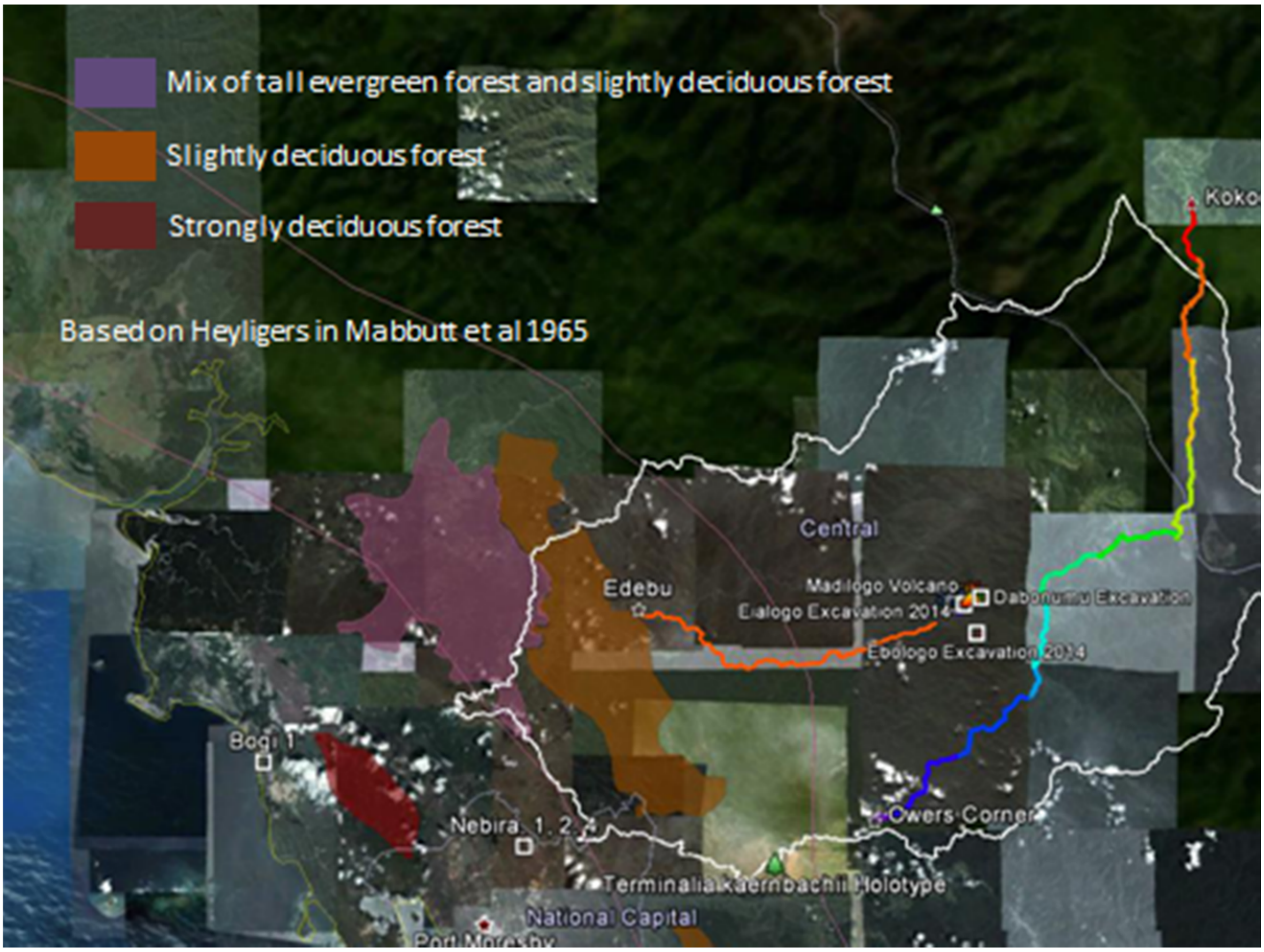


Figure 9. Google Earth image of the Kokoda IPZ and southern coast near Port Moresby. Superimposed on the image are the deciduous forest areas characterized by Mabbutt et al 1965. The fine purple lines indicate the key rainfall bands of 1.25 m (at the southern boundary of the IPZ) and 2.5 m (to the Northwest of Edebu). Also shown are the Kokoda Track and the track from Edebu to Madilogo (orange). Also indicated is the location of the Holotype for *Terminalia kaernbachii* (the herbarium specimen from which the species is defined).

If we follow Yen's 'extension of adaptation' hypothesis, we could expect the lowland/coastal deciduous forests to have held the primary ancestral population of okari, from which people expanded their range, translocating plants to the lower montane forest zone, and then tended trees and selected desirable traits, particularly nut size. With this hypothesis in mind, what evidence do we have for translocation, tending and harvesting processes? Firstly, okari seeds are too large for natural dispersal into the lower montane forests. Natural dispersers capable of transporting their large fruits are currently absent from Papua New Guinea. Natural dispersers may have included *Diprotodon* spp. or other megafauna species which occupied the region until the late Pleistocene.

Secondly, the genus *Terminalia* has relatively large amounts of nuclear DNA and often has differing levels of polyploidy (Ohri 1996). Some triploid species, for example, maybe apomictic, reproducing clones through unfertilized seeds. Clonal reproduction can often induce somatic mutations in plants which allow for rapid selection of desirable traits by humans. In addition, the wood of the polyploid species of *Terminalia* is lighter and grows more vigorously (Ohri 1996). The level of polyploidy is generally unknown across the *Terminalia* species of New Guinea, but it is thought to be higher in species growing in highly seasonal areas (e.g. the deciduous forest belts of lowland Central Province). Polyploidy can also indicate high levels of selection and rapid rates of species diversification, characteristic of domesticated species. This is to some degree evident from the provisional population genetic studies on *Terminalia cattapa* (talis) from Vanuatu, a close relative of the okari. Populations from specific valleys showed more variation within populations than between populations from neighbouring valleys, indicating higher local selection pressures (V. Lebot, pers. comm July, 2014).

Thirdly, evidence for a large increase in the abundance of fossil *Terminalia* pollen and possible phytoliths from the MDG034 assemblage at Eialogo (see Appendix 2) between 2800 and 2500 years ago, suggest that as this village was expanded, so too did *Terminalia* populations. Evidence for forest management and perhaps *Terminalia* arboriculture is also found within the microfossil data. Secondary forest taxa, mainly sub-canopy species that colonize disturbed forest patches, include species within the genera *Acalypha*, *Dodonaea*, *Macaranga* and *Trema* are strongly represented in the MDG034 record in association with *Terminalia*. Grass dominant vegetation is also recorded within our proposed period of *Terminalia* arboriculture (2800 to 2500 years ago) and is thought to have been usually influenced by human activities, primarily agriculture, although once established they are maintained by periodic burning. Our fossil data also show that other tall forest trees were excluded from the area providing robust evidence for the probable tending of *Terminalia* trees. Finally, our evidence for okari nut harvesting, based on the excavation of a possible anvil (nut-cracking stone) from the Eialogo Test Pit, further strengthen our case for okari arboriculture in the Naoro Valley.

In addition, okari arboriculture may have been intensified because large mammals, such as the wave of new pig introductions that may have arrived with Lapita colonization, that are capable of cracking okari nuts, may have competed with humans for this protein rich food. Such competition would probably have forced the people to keep track of each groves ripening season, so that they could pick the fruit before it fell or collect it from the ground immediately afterward— before nut predation by pigs, other animals, or other people.

Several caveats exist within our hypothesis, which will require an extensive population genetics study as well as further archaeological excavation data to be adequately addressed. Nevertheless, we have a strong case demonstrating the expansion of okari arboriculture after 2800 years ago. At present, it is not possible to determine from archaeological evidence if the okari found in the Naoro Valley are domesticated varieties, but several aspects of this tree species suggest probable domestication following human selection (e.g. for large fruits and polyploidy). We contend that with further archaeological research, several aspects of both okari domestication and arboriculture can be revealed providing a foundation for understanding long-term human subsistence in the lower montane zone.

KEY RESEARCH OUTCOMES

- **Earliest evidence of exchange with coastal communities (possibly Lapita-related) of obsidian (2800 years ago) into the montane valleys of Papua New Guinea.**
- **Evidence for the expansion of settlements as a proxy for agricultural (primarily indicated from microfossil evidence), but certainly arboricultural production in the Kokoda IPZ by 2800 years ago.**
- **Evidence for the expansion of okari nut arboriculture and possible evidence for processing 2800 years ago.**
- **Possible evidence for a shift in stone tool technologies and manufacture associated with interaction and exchange with coastal communities in the late Holocene.**

ONGOING RESEARCH PRIORITIES

- **Human landscape-use in the Pleistocene and Holocene**

The addition of four mid-late Holocene archaeological sites in the Naoro Valley will immediately allow us to improve our predictive GIS model, initially used to select the sites for excavation in the June 2014 season. This will be critical to the proposed hydro power development at Madilogo involving substantial earthworks (i.e. for the potential dam project). Our predictive model could further improve our ability to locate archaeological sites within the planned flood zone. As mentioned below, we still recommend field excavations of pre-flooding in certain locations in order to ensure the integrity of any potential archaeological sites found within the planned flood zone. We hope to have this prepared and sent to DEC for consideration by October 2014.

- **Trade and exchange**

The Naoro Valley obsidian flakes, currently determined from observational descriptions to be from West Ferguson Island will be quantitatively examined by Prof. Glenn Summerhayes of the University of Otago. Analysis to be completed by October 2014.

- **Extend and refine chronology of human occupation in the IPZ**

Further radiocarbon dates will be obtained from identified wood or nut-endocarp charcoal samples identified in the field (possible okari nut fragments) by Dr Matthew Prebble (ANU). These radiocarbon dates are currently funded through a RSAP research grant awarded to Dr Matthew Prebble as part of extending the research component of the Kokoda Initiative project. Basal archaeological charcoal samples have been submitted to the Direct AMS lab, Seattle, USA. Results from these analyses will be expected by October 2014.

- **Archaeological charcoal analysis**

Wood and endocarp charcoal are currently being analysed in order to provide data on fuel use (for domestic fires) and potentially the domestication, cultivation and harvest of okari nut. More material will be required from additional excavations in order to improve the interpretative value of these analyses.

- **Stone tool residue and use-wear analyses**

The Naoro Valley stone tool assemblage has been described using a technological analysis by Clair Harris (University of Queensland) and Dr Matthew Leavesley (JCU). These tools will be sent to the ANU for epi-illuminating microscope and scanning electron microscope analyses by Dr Matthew Prebble (ANU) to determine potential plant residues on each artifact. More artefacts will be required from additional excavations in order to improve the interpretative value of such analyses.

RECOMMENDATIONS FOR FURTHER ARCHAEOLOGICAL RESEARCH

- **Proposed dam flood zone archaeological impact mitigation**

Our predictive GIS model will be able to provide a detailed outline of areas within the planned flood zone that might hold archaeological value. Our current predictive model is based on a 30 m digital elevation model (DEM). Upon receiving the high resolution model housed by DEC (M. Keako pers. comm.), we hope to be able to provide a more precise predictive model that will provide DEC with the necessary data to make an informed decision about setting potential impact mitigation priorities.

- **Trade and exchange**

Our data suggest that obsidian is probably abundant within the Naoro Valley for the period dating to between 2800 and 2500 years ago. Identifying the extent of the obsidian exchange network that we contend existed between coastal Lapita-related communities and montane Papuan societies is of vital significance. This will require further excavation in other parts of the IPZ. It is also possible that Pleistocene hunter-gatherers also exchanged obsidian as has been documented in East New Britain, but this has yet to be established on mainland New Guinea.

- **Upper and Lower Naoro Valley Excavation (EAST- WEST excavations)**

Within the Naoro Valley, further archaeological research should be concentrated both up and down the catchment (EAST to WEST), focusing on both lower valley flats and ridgelines. The location of the ancestral village of Lo'o Tana, a village occupied before relocation to the ridgeline village of Dabonumu, prior to the arrival of the SDA Missionaries (M. Leavesley, Madilogo Field Notes, 2014), should be ascertained, given its importance to the present day people. Coastal and east ward connections should also be assessed by examining sites closer to Edebu.

- **The interplay between okari and karuka arboriculture in the montane zones (SOUTH to NORTH excavations)**

We strongly recommend that DEC encourage further research into the domestication history of okari, the totem tree of many Mountain Koiari communities. We believe that this tree not only has a domestication history unique to the IPZ, but with our evidence of probable arboricultural production and exchange extending back to 2800 years ago, may represent a defining point in the development of societies in the lower montane zone. In conjunction with further archaeological excavation of sites associated with okari nut production, we suggest that the extent these arboricultural systems should be mapped and a population genetic study conducted.

In addition, the extensive work conducted in the mid-montane Ivane Valley at Kosipe, focused on the analysis of karuka-nut Pandanus production in both the Pleistocene and Holocene should be replicated within the Kokoda IPZ. The Ivane Valley research has yet to provide archaeological data on the interaction between mid and lower montane societies, which we believe can be more immediately examined within the Kokoda IPZ. The IPZ provides an ideal location for developing hypotheses regarding the importance of nut production in Pleistocene and Holocene economies of montane Papua New Guinea. If demonstrated, as we believe is immediately achievable with further archaeological research, the archaeology of the Kokoda IPZ will provide a unique and globally significant model for the interaction and exchange between the hunter-gatherer/arboricultural (Papuan) societies with agricultural societies (Austronesians/Lapita).

ABBREVIATIONS

AMS	Accelerator Mass Spectrometry (Direct-AMS= radiocarbon dating lab employed)
ANU	Australian National University
DEC	Department of Environment and Conservation (Papua New Guinea)
DEM	Digital Elevation Model
IPZ	Interim Protection Zone
NMAG	National Museum and Art Gallery, Papua New Guinea
SDA	Seventh Day Adventist
UPNG	University of Papua New Guinea

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APPENDIX 1. TECHNOLOGICAL ANALYSIS OF ARTEFACTS: TABLE

By Clair Harris and Matthew Leavesley

Site	Depth (cm below surface)	Artefact Type	Material	Broken or Complete	Weight (g)
Dabunumu	5 - 15	Complete Flake from Marble	Glass	Complete	0.31
	25 - 35	Bipolar Core	Quartz	Complete	2.05
	30 - 35	Complete Flake	Obsidian	Complete	0.07
	35 - 45	Complete Flake	Quartz	Complete	1.5
	45 - 55	Complete Flake	Quartz	Complete	0.78
	65 - 75	Broken Flake	Quartz	Broken	0.15
Eialogo	25 - 35	Broken Flake	Quartz	Broken	0.17
		Broken Flake	Quartz	Broken	0.15
	55 - 65	Broken Flake	Quartz	Broken	0.81
	60 - 65	Complete Flake	Obsidian	Complete	1.73
		Ground Edge Axe Fragment	Volcanic (Basalt)	Broken	9.94
		Flake	Volcanic	Complete	1.63
	65 - 70	Ground Edge Axe	Volcanic (Basalt)	Complete	46.81
	75 - 85	Broken Flake	Volcanic	Broken	1.89
	85 - 95	Broken Flake	Volcanic	Broken	0.7
		Complete Flake	Quartz	Complete	0.13
Ebologo	0 - 5	Complete Flake	Quartz	Complete	0.19
	5 - 15	Bipolar Core	Quartz	Complete	4.6
		Bipolar Core	Quartz	Complete	3.96
		Bipolar Core	Quartz	Complete	0.72
		Bipolar Flake	Quartz	Complete	0.5
		Complete Flake	Quartz	Complete	0.37
		Complete Flake	Quartz	Complete	0.2
		Complete Flake	Quartz	Complete	0.02
		Complete Flake	Quartz	Complete	0.01
		Broken Flake	Sedimentary	Broken	15.83
		Retouched Flake	Volcanic	Complete	13.4
		Complete Flake	Volcanic	Complete	0.85
		Complete Flake	Quartz	Complete	0.07
		Bipolar Core	Quartz	Complete	19.14
		Bipolar Core	Quartz	Complete	4.42
		Bipolar Core	Quartz	Complete	1.04
		Bipolar Core	Quartz	Complete	1.09
		Flake	Quartz	Complete	1.09
		Flake	Quartz	Complete	0.57
		Flake	Quartz	Complete	0.44
		Flake	Quartz	Complete	0.49
		Flake	Quartz	Complete	0.31
		Flake	Quartz	Complete	0.55
		Flake	Quartz	Complete	0.13
		Flake	Quartz	Complete	0.15
		Flake	Quartz	Complete	0.09
	15 - 25	Flake	Volcanic	Complete	1.82
		Flake	Volcanic	Complete	4.54
	25 - 35	Ground Object	Volcanic	Complete	17.95
		Broken Flake	Chert	Broken	0.42
		Bipolar Core	Quartz	Complete	1.34
		Flake	Quartz	Complete	2.78
		Flake	Quartz	Complete	0.79
		Flake	Quartz	Complete	0.42
		Flake	Quartz	Complete	0.48
		Flake	Quartz	Complete	0.29
		Ground Object	Volcanic	Complete	8.01
		Flake	Volcanic	Complete	16.53
	35 - 45	Broken Flake	Quartz	Broken	0.53

Site	Depth (cm below surface)	Artefact Type	Material	Broken or Complete	Weight (g)
Eiaiafaha	0 - 10	Complete Flake	Quartz	Complete	0.43
		Complete Flake	Quartz	Complete	1.18
		Complete Flake	Quartz	Complete	0.34
		Complete Flake	Quartz	Complete	0.23
	10 - 20	Broken Flake	Quartz	Broken	0.34
		Core	Quartz	Complete	8.39
		Complete Flake	Quartz	Complete	1.22
		Complete Flake	Quartz	Complete	0.17
		Complete Flake	Quartz	Complete	0.24
		Complete Flake	Volcanic	Complete	1.23
		Broken Flake	Chert	Broken	0.57
	20 - 30	Core	Quartz	Complete	21.27
		Complete Flake	Quartz	Complete	4.94
		Complete Flake	Quartz	Complete	1.06
		Complete Flake	Quartz	Complete	1.06
		Complete Flake	Quartz	Complete	0.7
		Broken Flake	Quartz	Broken	0.63
		Complete Flake	Volcanic	Complete	0.53
		Complete Flake	Volcanic	Complete	0.81
		Complete Flake	Quartz	Complete	0.34
		Complete Flake	Quartz	Complete	0.39
		Complete Flake	Quartz	Complete	0.99
		Complete Flake	Quartz	Complete	1.18
		Complete Flake	Quartz	Complete	0.52
		Complete Flake	Quartz	Complete	0.49
		Complete Flake	Quartz	Complete	0.44
	30 - 40	Bipolar Core	Quartz	Complete	2.44
		Complete Flake	Quartz	Complete	1.48
		Complete Flake	Quartz	Complete	1.72
		Complete Flake	Quartz	Complete	0.58
		Complete Flake	Quartz	Complete	0.31
		Complete Flake	Quartz	Complete	0.13
		Bipolar Flake	Quartz	Complete	0.66
		Complete Flake	Quartz	Complete	0.34
		Complete Flake	Quartz	Complete	0.24
		Broken Flake	Volcanic	Broken	2.55
		Complete Flake	Volcanic	Complete	9.99
		Bipolar Core	Quartz	Complete	2.64
		Bipolar Core	Quartz	Complete	2.74
		Complete Flake	Quartz	Complete	0.86
		Complete Flake	Volcanic	Complete	1.9
	40 - 50	Broken Flake	Quartz	Broken	0.12
		Broken Flake	Quartz	Broken	0.02
		Complete Flake	Volcanic	Complete	0.03
		Bipolar Core	Quartz	Complete	10.48
		Broken Flake	Quartz	Complete	25.83
	50 - 60	Complete Flake	Volcanic	Complete	2.98
	60 - 70	Complete Flake	Volcanic	Complete	0.7
		Complete Flake	Quartz	Complete	0.41
		Complete Flake	Quartz	Complete	0.38
	80 - 90	Bipolar Flake	Volcanic	Complete	0.35

APPENDIX 2. MICROFOSSIL ANALYSIS OF EIALOGO SEDIMENTS

By Mark Walker and Matthew Prebble

The Mountain Koiari people of Madilogo have a tradition of village abandonment and relocation in times of political, social and domestic pressure (Prebble et al 2013). These abandoned villages include Dabonumu, Eialogo, Tubelogo and Old Madilogo, the latter a name determined from early 20th century survey maps and from local informants form part of this village relocation sequence. The ancestral village apparently began at Dabonumu and tracked down the Eia Creek, reaching the modern Ma i Madilogo. In December 2012 a series of sites adjacent or within Eialogo, Tubelogo and Old Madilogo villages were augered for organic sediments. Stratified plant microfossil remains were examined from these sediments to determine the influence of human-led vegetation change over time, as a potential indicator of occupation abandonment time. The most organic sediment retrieved was from a single augured core (MDG004), taken directly from the site identified as Eialogo. In this appendix we outline the methods and results of these analyses, but discuss the implications of this record in the main text. This research formed part of a Masters of Archaeological Science (ANU) research project conducted by Mark Walker under the supervision of Dr Matthew Prebble.

Sample Collection and Preparation

Samples for this analysis were obtained from the MDG004 site using an extendable hand augur. These samples were taken to the maximum depth possible (before hitting rock) and were collated separately into individually labelled sample bags. Each sample-filled bag weighed approximately 200g. Sediment descriptions were recorded including texture, colour and pH, with microscopic examination of organic inclusions conducted in the lab (*Appendix 2, Table 1*.)

Sub-samples of 1cm^3 were prepared in the lab. Each representing a particular sample depth (1-15 : 0-92cm). For the purposes of analysis, separate samples were processed for phytoliths, palynomorphs (pollen and spore), charcoal particles, volcanic inclusions and magnetic susceptibility analyses.

Pollen Analysis

Pollen preparation throughout this study was carried out according to methods outlined by Traverse (2007). Samples of 3cm^3 were processed with KOH (10%), $Na_4P_2O_7$ (5%), HCL (10%) and an acetic acid mixture – a 1:9 ratio of Sulphuric Acid [H_2SO_4] to Acetic Anhydride [$(CH_3CO)_2O$]. HF (50%) treatment was utilised to remove silicates. Throughout, samples were washed in de-ionised water between each step. *Lycopodium clavatum* (tablets of 20,048 spores) spores were added to each sample as an exotic marker for the purposes of concentration analysis and sample size estimation.

Post processing, palynomorph samples were mounted evenly on glass slides and subject to individual taxa identification under a 400x microscope. For the purposes of identification, reference materials were obtained from sources including the reference collection present at the Australian National University, the Indo-Pacific Pollen Database (http://palaeoworks.anu.edu.au/databases.html) and the Australasian Pollen and Spore Atlas (http://apsa.anu.edu.au/). These data are presented in *Appendix 2 Figure 2 and 3*, with the results summarised in *Appendix 2, Table 3*.

Zone	#	Depth (CM)	14C Date (BP)	PH	Munsell	Texture	Inclusions (Organic)
1	1	0-14		6	2.5 YR 3/4	Fine silt	Algae, rootlets (common)
	2	14-22		5.5	2.5 YR 3/4	Fine silt	Algae, rootlets (common)
	3	22-30		5	2.5 YR 3/4	Medium to fine silt	Algae, rootlets (common)
	4	30-37		5.5	2.5YR 3/2	Medium to fine silt	Algae, rootlets (common)
2	5	37-44		5	N 3/0	Very fine silt	Algae, rootlets (common)
	6	44-51	870 +/-23	5	N 3/0	Medium to fine silt	Algae, rootlets (common)
	7	51-60	2759 +/-26	5.5	N 3/0	Medium to fine silt	Algae, rootlets (uncommon)
3	8	60-66		6	5YR 2/2	Medium silt	Algae, rootlets (uncommon)
	9	66-73		5	5YR 2/2	Medium silt	Algae, rootlets (uncommon)
	10	73-79		5	5YR 2/2	Medium silt	Algae, rootlets (uncommon)
	11	79-83		5	7.5YR 4/2	Medium silt	Rootlets (uncommon)
	12	83-92		6	7.5YR 6/2	Medium to fine silt	Rootlets (rare)
	13	92-98	2789 +/-41	6.5	7.5YR 8/2	clay	None visible
4	14	98-105		5	7.5YR 8/2	clay	None visible
	15	105-111		5.5	7.5YR 8/2	clay	None visible

Appendix 2 Table 1. Auger log and sediment descriptions including the radiocarbon ages obtained from bulk organic sediment samples.

Phytolith Preparation

Following techniques outlined by Piperno (2006), samples for phytolith identification were subject to a bath of hydrogen peroxide in order to remove any organic content. An ultrasonic bath was then used to separate any clays from the phytoliths. In order to remove coarser material, the solution was then wet-sieved through a 250µm mesh. Manual deflocculation (settling and decantation in distilled water) was used to remove particles <5µm. A solution of 2.3 kg l-3 specific-gravity Sodium-Polytungstate was utilised as a gravity separating agent for phytolith extraction.

Samples were then mounted on glass slides and subject to morphotype identification under a 400x microscope. Throughout, individual morphotypes were collated into a matrix that eventually comprised some 117 differently identifiable shapes – demonstrating variant forms such as differing bulliform types, point types and other morphotypes. Attempts were made, where permissible, to identify phytoliths that could be representative of individual taxa. In an effort to maintain consistency throughout, the identification and collation stage, morphotypes were identified schematically from the ICPN working groups International Code for Phytolith Nomenclature (Madella et al., 2005) and nomenclature derived from Bowdery (1998), Barboni (2007) and Twiss (1969). These data are presented in *Appendix 2 Figure 2 and 3,* with the results summarised in *Appendix 2, Table 3.* Some images of the main phytolith types presented in *Appendix 2, Figure 3*.

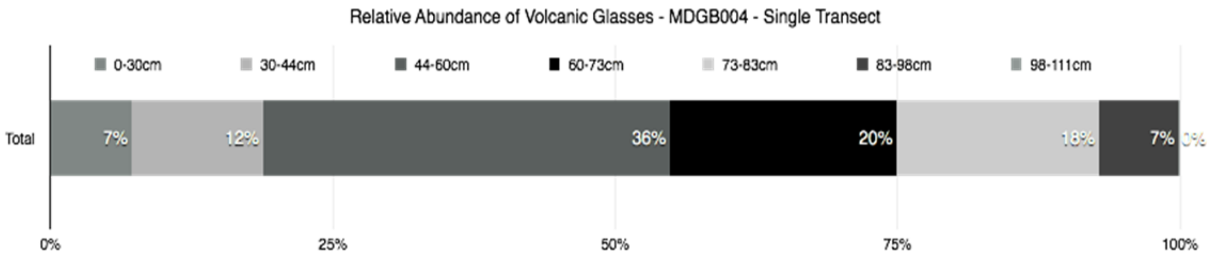
Charcoal & Glass Analysis

Bleach (Sodium Hypochlorite – NaOH) was added as an agent to remove colour from organic compounds (Ali et al 2009). Each vial was filled to near capacity and manually agitated. Samples were allowed to rest for 1 week. These were further agitated intermittently throughout the week. Once the sediment decreased in opacity it was prepared for manual counting under a microscope. This process involved transferring the particles to two petri dishes. These dishes of samples were prepared by sieving the sample through alternate 125µm and 250µm sieves.

The prepared dishes were then placed upon a square grid and examined through a binocular microscope (approximately x10 – 15 magnification). Angular back opaque non-reflective particles were counted by eye using a hand counter as an aid. The final result is expressed as an absolute count.

Subsequent to charcoal counts, each sample was examined for the presence of non-biogenic silicates by pipetting the mixture onto a series of slides. These chiefly took the form of black/blue semi-opaque glasses that fractured to reveal mostly-transparent shards under pressure. A single transect of each was conducted and represented as a proportion of ~10,000 individuals (the total count for the combined slides). These data are presented in *Appendix 2 Figure 2 and 3* with the results summarised in *Appendix 2, Table 3.*

Non-biogenic silicates are present throughout the assemblage. These predominately take the form of dark semi-opaque to opaque crypto-crystalline shards with translucent edges. With a maximum limit of ~200μm the shards varied considerably in size and were also subject to fracturing and splintering under pressure. Upon examination under a microscope, conchoidal fractures were evident throughout the record. *Appendix 2 Figure 1* provides a representation of proportions throughout the assemblage.



Appendix 2, Figure 1. Glass counts from the MDG004 assemblage – expressed in proportional concentrations from a total of ~10,000 counts identified from throughout the auger record.

Magnetic Susceptibility

Sub-samples (from the original sample collection) were collated into volumetric samples of 1cm³ and placed into water-tight capped vials and labelled according to sample depth. These samples were left in a raw unprocessed or modified state and were deemed to be representative of a ~7.5cm portion of the total augur depth respectively.

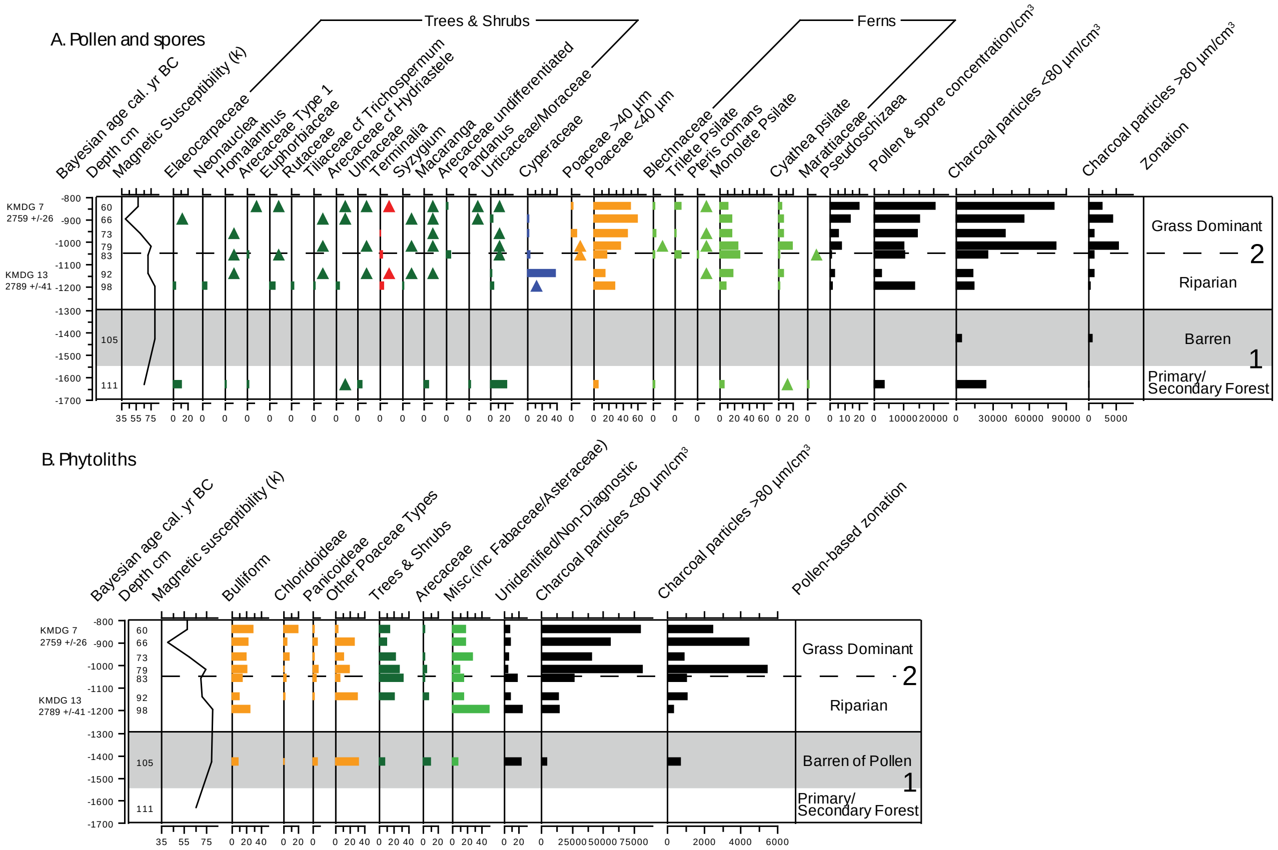
Each sample was then read by a magnetic susceptibility meter (Bartington Instruments Multisus Sensor – MS2C). Background readings were taken at the beginning and end of the session to account for variations in external magnetic influence. Data entries were recorded by the MS2C software, running on a Windows XP laptop, automatically. This software was responsible chiefly for calibrating and collating the data. Drift warning level was set at 10 and throughout the procedure no instances of drift warning were encountered during readings. These data are presented in *Appendix 2 Figure 2 and 3* with the results summarised in *Appendix 2, Table 3.*

Radiocarbon dating

Three dates were obtained from bulk samples at (6) 43-51 cm, (7) 51-60 cm and (13) 92-98cm. These dates were calibrated using IntCal13 on the OxCal 4.2 program (Bronk Ramsey 2001; see *Appendix 2 Table 2.)* and placed into a Bayesian deposition model, presented in *Appendix 2 Figure 2 and 3*.

Lab no.	**Sample**	**C13**	**% Modern**	**% Modern error**	**C14 age**	**age error**
D-AMS006729	KMDG 6 (51)	-26.60	89.73/0.26	0.26	870	23
D-AMS003767	KMDG-7 (60)	-5.20	70.93/0.23	0.23	2759	26
D-AMS003768	KMDG-13 (98)	-25.00	70.67/0.36	0.36	2789	41

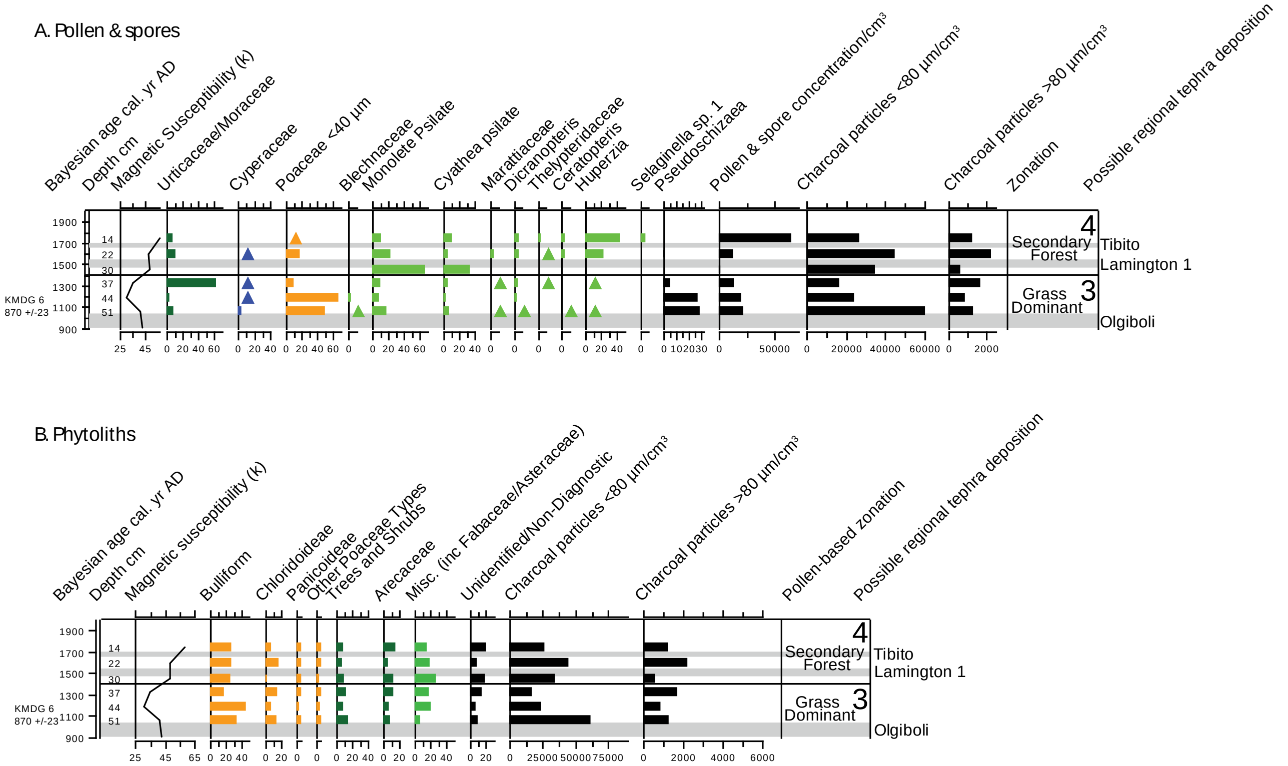
Appendix 2, Table 2. Radiocarbon dates for the Eialogo MDG004 auger record.



Appendix 2, Figure 2

A. Stratigraphic diagram of pollen and spores from 111 to 55 cm of the Eialogo Auger (MDG004) representing the period from 1700 to 800 BC. Presented are the most abundant pollen and spore types, *Pseudoschizaea* resting spores and charcoal particles. Three zones are indicated: Secondary Forest zone from 1700 to 1300 BC, characterised by poor pollen and spore preservation; the Riparian, from 1300 to 1050 BC, and Grass Dominant zone from 1050 to 800 BC. Taxa highlighted in green are trees and shrubs; in light green are ferns and fern allies. *Terminalia* pollen (probably from Okari) is highlighted in red, marking the expansion of this important tree crop from ~1800 BC onwards.

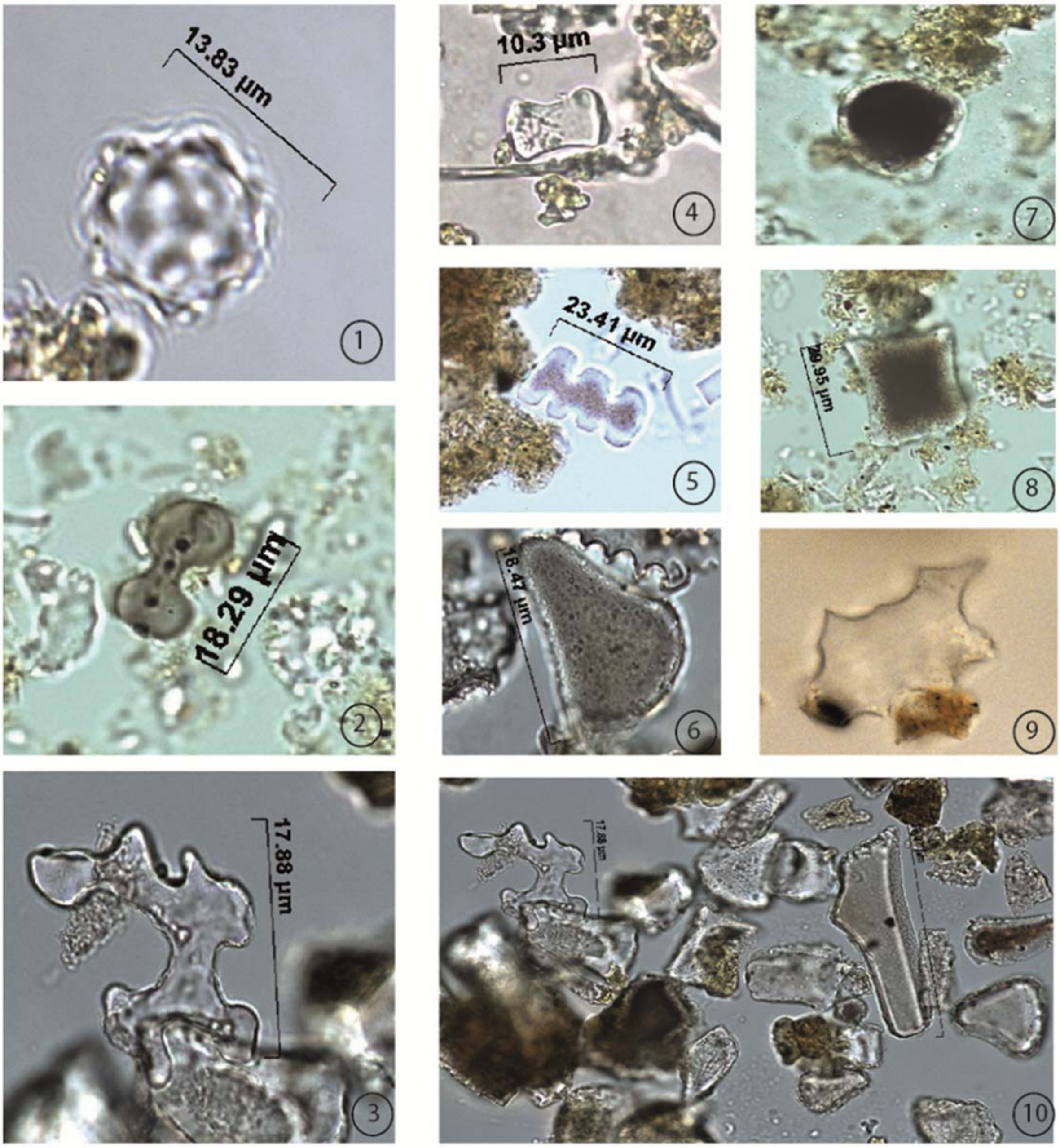
B. Stratigraphic diagram of phytoliths from 111 to 55 cm of the Eialogo Auger (MDG004) representing the period from 1700 to 800 BC. Presented are the main phytolith types represented and the same charcoal particle data obtained from the pollen and spore preparations. The same zones are presented as identified from the pollen and spore record.



Appendix 2, Figure 3

A. Stratigraphic diagram of pollen and spores from the top 55cm of the Eialogo Auger record (MDG004) representing the period from 800 AD to the present. Presented are the most abundant pollen and spore types, *Pseudoschizaea* resting spores and charcoal particles. Two zones are indicated: Grass Dominant zone from 800 to 1400 AD and a Secondary Forest zone from 1400 to the present. Also indicated are the regional timing for key volcanic ash-fall events

B. Stratigraphic diagram of phytoliths from top 55cm of Eialogo Auger (MDG004) representing the period from 800 AD to the present. Presented are the main phytolith types represented and the same charcoal particle data obtained from the pollen and spore preparations. The same zones are presented as identified from the pollen and spore record.



Appendix 2, Figure 4. Examples of phytoliths from the MDG004 assemblage (with depth indicated). 1) Globular Echinate (Aracaceae) [22-30cm] 2) Bilobate with encapsulated carbon (Poaceae) [30-37cm] 3) Irregular type (Arboreal) [79-83cm] 4) Saddle (Poaceae) [44-51cm] 5) Multi-lobate (Poaceae) [14-22cm] 6) Fan Bulliform (Poaceae) with carbon inclusions [44-51cm] 7) Ovate with encapsulated carbon (Trees/Shrubs) [79-83cm] 8) Scutiform with encapsulated carbon (Poaceae) [73-79cm] 9) Irregular type (Arboreal) [79-83cm] 10) Phytolith diversity at depths of 79-83cm.

Zone / Depth (cm)/14C age	**Phytoliths**	**Pollen and Spores**	**Summary Interpretation**
Zone 1 : (98-111) Primary/Secondary Forest	Very minor phytolith presence, of which scutiforms (poaceae) dominate. All phytoliths are poorly preserved. Magnetic susceptibility readings are at their highest point during this zone indicating high mineral concentrations, especially of iron oxides. Charcoal is recorded in relatively low concentrations in this zone	*Poaceae* pollen is minimal throughout this zone, although the upper part of the zone is barren of pollen Taxa are generally more representative of *Ulmaceae* (*Trema* and *Celtis*), *Macaranga*, *Elaeocarpaceae* and *Moraceae*. Ferns types are present but in small percentages. *Terminalia* pollen is absent in this zone.	Microfossil preservation is limited, but the preservation of high proportions of Elaeocarpaceae (indicative of primary forest) and low charcoal concentrations may indicate less forest modification
Zone 2 : 60-98 Riparian (83–98) Grass Dominant (60-83) .	Poaceae reaches the highest abundance of the record (61%) as a result of an increase in scutiform types which are less common in the upper zones. Bulliform types decline in abundance as Scutiform types increase. Arecaceae are under-represented throughout the zone. Tree and shrub taxa decrease from the base of the zone from a peak of 32%. Miscellaneous forms are at their highest representation in this zone. Both Panicoideae and Chloridoideae fluctuate throughout this period. Charcoal particles are high comparative to previous zones. Within the Riparian part of the zone, there is a marked decline in phytolith presence as the sediment changes in colour and texture.	Poaceae pollen and Monolete Psilate spores first appear in high proportions in this zone. Uriticaceae/Moraceae, Euphorbiaceae, Arecaceae, *Neonauclea* and *Terminalia* are common in the basal 'riparian' part of this zone. High proportions of Cyperaceae pollen between 83- 92 cm indicate local riparian conditions at this time. The upper 'grass dominance' part of this zone is characterised by high proportions of grass pollen, *Pseudoschizaea* resting spores and the highest concentrations of charcoal particles found throughout the record.	Transition from arboreal to grass dominance towards the top of this zone indicating a more open, non-forest environment. This observation is supported by the presence of abundant *Pseudoschizaea* resting spores. The increase in magnitude of burning events suggests forest clearance, potentially for the expansion of village and garden sites. The Poaceae phytolith record changes composition from scutiform dominated towards bulliform prevalence. Many tree and shrub taxa are only recorded in the pollen record of this zone. *Terminalia* pollen (probably of *Okari*) is most strongly represented in this zone.
Zone 3 : (37-60) Grass Dominant	High proportions of fractured, pitted and scarring on phytoliths. Arecaceae types are abundant throughout the zone. Charcoal concentrations are high in this zone, peaking at its centre before levelling off again towards the end. This increase is sharper for values <80µm with a more gentle increase being applicable for larger particles.	Increased abundance of Poaceae forms. *Dicranopteris* are present throughout but lower in instance than in zone 1. *Blechnaceae* fern types are a notable introduction to this zone. Many of the main forest tax represented in the previous zones are either absent or rare in this zone e.g. E*laeocarpaceae, Pandanus* and *Ficus*. *Pseudoschizaea* is found in high proportions in this zone. *Terminalia* and *Arecaceae*, are present in this zone but in low proportions.	Poaceae type phyoliths and pollen are abundant in this zone but decrease towards the top as palm phytoliths and Urticaceae/ Moraceae pollen increase. Trees and shrubs remain consistent throughout this zone but have a comparatively low presence. *Pseudoschizaea* indicates an open environment that is seasonally dry.
Zone 4: (0-37) Secondary Forest/900-	High proportions of charred, pitted and fractured bulliforms and bilobates; Poaceae types peak at 14-22cm, comprising 61% of the assemblage. Bilobates are represented throughout	Fern and fern allies dominate this zone –including *Cyathea*, *Dicranopteris* and *Huperzia*. The upper part of the zone is notable for containing	A mixed mosaic of vegetation types are presented in this zone. Poaceae are common, particularly as fan-shaped bulliforms, Panicoideae

Zone / Depth (cm)/14C age	Phytoliths	Pollen and Spores	Summary Interpretation
1200	the zone in relatively small quantities (peaking at 9% of the Poaceae assemblage). Saddle forms (Poaceae – predominately Chloridoideae) are also present. They dominate the latter part of the zone. Trees, shrubs and palms are generally abundant apart. Arecaceae, Fabaceae, Asteraceae and some other miscellaneous types are recorded in their highest proportions in the top of the zone. Charcoal particles are found in comparatively low concentrations.	abundant *Ceratopteris* pollen. Poaceae are recorded in low proportions throughout this zone as are tree and shrubs.	Chloridoideae. Of the arboreal assemblage, Arecaceae dominate most of the zone, although numbers of other arboreal taxa still remain.

Appendix 2, Table 3 Summary of phytolith, pollen and spore record of the MDG004 auger sediments from Eialogo. The implications for these data are discussed in the main report.

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APPENDIX 3. SITE LOCATIONS

MDG Site no.	Site name	Latitude	Longitude
1	Ma-i Madilogo - Vogira's hamlet	9°12'6.27"S	147°33'20.04"E
2	Ma-i Madilogo - Vogira's hamlet	9°11'57.44"S	147°32'58.81"E
3	Kaiavu Water Fall	9°11'53.98"S	147°32'56.25"E
4	Lower Old Madilogo	9°11'49.18"S	147°33'5.51"E
5	Central Old Madilogo	9°11'48.70"S	147°33'8.62"E
6	Central Old Madilogo	9°11'47.80"S	147°33'9.55"E
7	Tubelogo	9°11'45.66"S	147°33'7.92"E
8	Tubelogo	9°11'45.61"S	147°33'8.76"E
9	Tubelogo	9°11'45.78"S	147°33'9.24"E
10	Tubelogo	9°11'46.91"S	147°33'15.26"E
11	Eialogo	9°11'41.58"S	147°33'25.08"E
12	Eialogo	9°11'41.87"S	147°33'26.10"E
13	Eialogo	9°11'40.95"S	147°33'26.97"E
14	Eialogo	9°11'40.66"S	147°33'27.08"E
15	Eialogo	9°11'39.86"S	147°33'27.98"E
16	Old Madilogo	9°11'48.06"S	147°33'18.75"E
17	East of (Ma-i) Madilogo	9°12'4.93"S	147°33'24.16"E
18	Eialogo	9°12'15.23"S	147°33'40.40"E
19	*Proximate to World Bank Dam* Wall	9°12'24.53"S	147°33'43.37"E
20	World Bank Dam Wall	9°12'27.71"S	147°33'49.12"E
21	Kabi MOIA's garden	9°12'3.28"S	147°33'36.05"E
22	Vavuvi	9°12'8.45"S	147°33'52.38"E
23	Vokanolo	9°11'57.28"S	147°33'25.48"E
24	Hamutenumu	9°11'51.87"S	147°33'27.60"E
25	n/a Near Tubelogo	9°11'55.79"S	147°33'23.45"E
26	n/a	9°11'55.77"S	147°33'22.89"E
27	n/a	9°11'53.57"S	147°33'22.46"E
28	n/a	9°11'48.67"S	147°33'18.00"E
29	n/a	9°11'51.93"S	147°33'16.19"E
30	(Ma-i) Madilogo - Vogira's hamlet	9°12'6.11"S	147°33'15.62"E
31	(Ma-i) Madilogo - Vogira's hamlet	9°12'6.35"S	147°33'21.03"E
32	Old Madilogo	9°12'3.51"S	147°33'20.67"E
33	Tubelogo	9°11'55.72"S	147°33'22.83"E
34	Eialogo	9°11'39.72"S	147°33'27.79"E
35	Kabi MOIA's garden	9°12'3.51"S	147°33'34.61"E
36	Kabi MOIA's garden	9°12'2.60"S	147°33'37.92"E

MDG Site no.	Site name	Latitude	Longitude
37/2014	Eiaiafaha TP1	9°11'38.73"S	147°32'59.29"E
38/2014	Ebologo TP1	9°12'59.78"S	147°34'3.06"E
39/2014	Madilogo Caldera	9°11'46.82"S	147°33'50.40"E
40/2014	Dabonumu TP1	9°11'20.66"S	147°34'13.78"E
41/2014	Eialogo TP1	9°11'39.72"S	147°33'27.79"E

APPENDIX 4. ADDITIONAL INFORMATION

OWEN STANLEY RANGE ARCHAEOLOGICAL SUMMARY

45 Ka Kosipe Sequence: Initial Pleistocene colonisation of the Owen Stanley Range at Kosipe, Ivane Valley, Central Province (Summerhayes et al., 2010).

25-14 Ka Kosipe Sequence: Occupation hiatus in mid to upper montane areas associated with extreme climate conditions of the Last Glacial Maximum (Hope, 2009)

10 Ka - Touku Sequence: Occupational sequence poorly described; significant movement of people and adaptation to lower montane areas in the Holocene; probably the introduction of root crops after 3000 years BP; (Hope and Prebble, in prep).

2800 years BP Caution Bay Sequence Austronesian/Lapita occupation at Caution Bay and surrounds (David et al., 2011).

2800 years BP Madilogo Sequence: Expanded village life, okari nut arboriculture and stone tool exchange (obsidian and chert) with Austronesian/Lapita communities at Caution Bay and surrounds (This report).

MADILOGO ENVIRONMENTAL EVENTS

~4200 years BP Ash 2 from the Touku sequence (Hope and Prebble in prep).

1500 AD Ash 1 from the Touku sequence (Hope and Prebble in prep), Possibly represented in Eialogo deposit.

1690 AD Tibito ash, marked across Papua New Guinea in many lake and swamp sequences. Possibly represented in Eialogo deposit.

1951 AD Mt Lamington erupts depositing ash as far as Port Moresby. Possibly found at the surface of all villages in the Madilogo Flats.

KOIARI POST-EUROPEAN CONTACT TIMELINE TO WWII

1879 Rev James Chalmers expedition with Andrew Goldie into Mountain Koiari territory. August 2nd describes the consumption of okari nuts (late in the season) at 720 m in elevation and the placement of tree burials. Illustrates what appears to be an okari tree-house. Also describes the reticence of his guides in entering into certain valleys. Describes the movement of villages with the passing of a chief.

1887 Henry Forbes expedition down the Naoro River and possibly up the Eia Creek to Dabonumu and then to Mt Ginianumu (Trotter, 1890). Dense population noted.

1908-10 Annual Reports say 'severe dysentery' in the 'main range': death rate unknown.

1913 Missionaries Septimus Carr, Lawson and Benny Tavodi visit inland villages establishing Seventh Day Adventist churches among the Mountain Koiari

1942 Naoro Valley used for air drops during the allied campaign in WWII

ARCHAEOLOGICAL RESEARCH TIMELINE

2012 M. Leavesley, H. Mandui, E. Kaitokai and M. Prebble archaeological survey of Madilogo. This is the first archaeological survey of the Mountain Koiari Region of Central Province.

2014 M. Leavesley, A. Kuaso, M. Keako and M. Prebble archaeological excavations conducted at Eiaiafaha, Eialogo, Ebologo and Dabonumu. These are the first archaeological excavations conducted in the Mountain Koiari Region of Central Province.