

Palaeo-environmental reconstruction of the Lake Ngami Basin, Botswana – the role of climate change in human biogeography

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List of Abbreviations

HOORC – Harry Oppenheimer Okavango Research Centre

ESA - Early Stone Age (from earliest stone tool making times ca. 2 000 000 years ago to 250 000 years ago)

MSA - Middle Stone Age (ranging from about 250 000 years ago to the beginning of the Late Stone Age)

LSA - Late Stone Age (ranging from most recent stone-using periods to 40 000 years ago)

LOI – loss on ignition

MOZ – Makgadikgadi-Okavango-Zambezi

PNSB – palaeo-lake Ngami sub-basin

1. Introduction

The Palaeo-Lake Ngami Sub-Basin (PNSB) is one of three sub-basins associated with the through-flow of water in a large structural depression referred to as the Makgadikgadi-Okavango-Zambezi (MOZ) basin (Ringrose et al., 2005). The MOZ basin (Figure 1), which forms the southernmost extension of the East African rift system, is itself sensitive to palaeo-climatic variation as from Tertiary time onward it received endoreic drainage from rivers draining the Angolan plateau. Subsequent filling and desiccation associated with hypersaline-alkaline conditions in the Makgadikgadi sub-basin have been recently dated using TL techniques as recurring around 100 000 BP, 80 000 BP and 40 000 BP (Ringrose et al., 2005) with other C¹⁴ dates identifying wetter and drier periods of lessening intensity from 40 000 BP until the present.

Lake Ngami, has a complex suite of shorelines ranging from the lake bed at 919m up to 945m asl (Shaw et al., 2003). The 3000 km² Lake Ngami, was still a substantial lake when visited by European travellers from 1849 onwards. Schwartz (in Shaw et al., 2003) consider the decline of Lake Ngami, which is presently dry, as evidence for increasing aridity in the southern African climate.

This project aimed to reconstruct PNSB environments during the Quaternary era and link these changes to patterns of human habitation around the lake basin. Coulson and Walker, 2003 report a series of test holes for gravel excavation along sand ridges in the western portion of the basin near Kareng. The general area around the test pits at Kareng was found to be very rich archaeologically and surface material found in the vicinity represents a number of archaeological periods from the Late Stone Age to the Iron Age.

Palaeo-environmental reconstructions were conducted in the Kareng region and near the lake sump in order to be able to link climate change with human biogeography. A series of pits on the palaeo-shoreline features near Kareng were excavated in December, 2004. Detailed sediment sampling was conducted and samples have now been analysed for palaeo-environmental reconstruction:

This work aimed to provide data on climate change in central southern Africa by:

- Obtaining corroborative dating and geochemical evidence for more humid and drier episodes in the Quaternary
- Relating past climate to patterns of early human habitation in the vicinity of the Lake Ngami Basin
- Indicating what might be reasonably anticipated with respect to swings in regional climates in order to better understand the present and for predicting future climatic conditions.

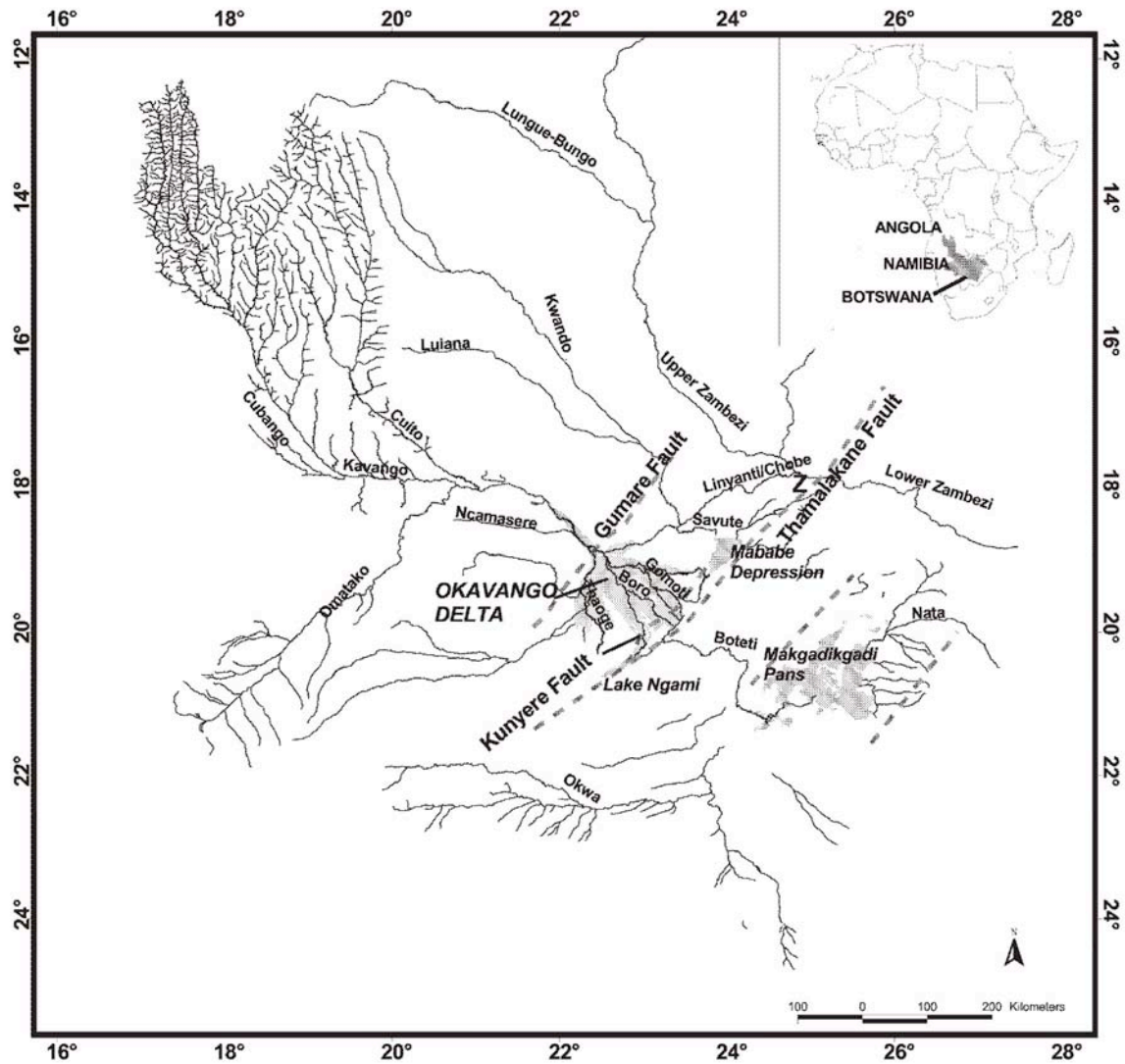


Figure 1. Makgadikgadi-Okavango-Zambezi basin, showing the Lake Ngami sub-basin to the south-west.

2. Materials and methods

For this START funded project, the work centered on:

- 1) Conducting geochemical analyses on KNG-01 pit (shown in Figure 2)
- 2) Conducting geochemical analyses on samples collected from the archaeologists test pits (Kareng Square IV, V and VI) near Kareng (Figure 2)
- 3) and continuing work on NG-02 pit (shown in Figure 2).

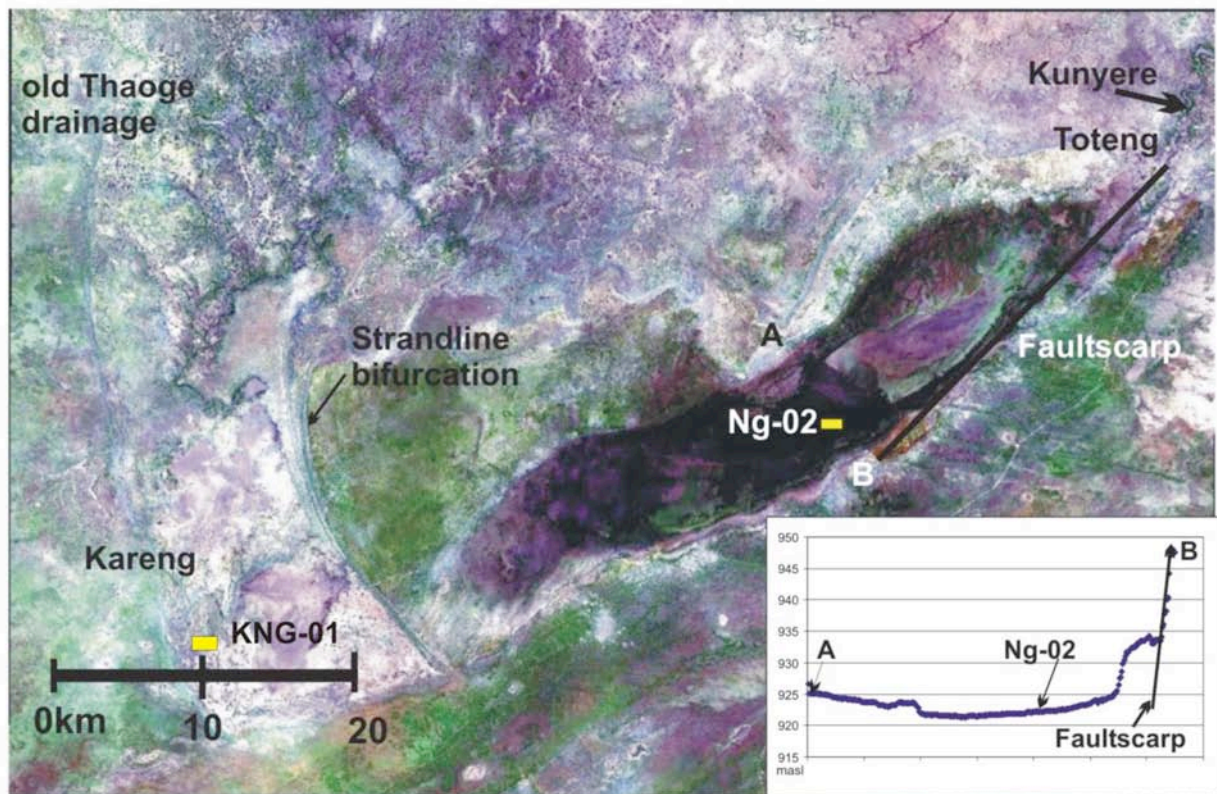


Figure 2. Lake Ngami sub-basin showing location of Ng-02 close to the lake sump and KNG-01 in the western, older part of the lake bed.

2.1 KNG-01

For the KNG-01, 37 samples were sieved and the <math><63 \mu\text{m}</math> fraction of each sample was then analysed for major elements using ICP-AES and trace and rare earth elements using ICP-MS. Samples were analysed at the Universite de Bretagne Occidentale where the principal investigator has been collaborating for a number of years.

Sulphur and organic and inorganic carbon were determined on the KNG-01 samples at the Harry Oppenheimer Okavango Research Centre (HOORC) laboratories.

Samples for Optical Spin Luminescence dating were sent to the Physics Department of the University of Botswana. Gastropods were collected from a number of horizons from the KNG-01 and it was our intention to date them using U/Th dating techniques. Unfortunately we have not yet identified a laboratory able to do this. We have however, attempted to identify the genus of the gastropods as an indicator of palaeo-hydrological conditions.

Samples for diatom analysis have been sent to the University College London.

2.2 Kareng Square IV, V and VI

These samples were collected by Coulson and Walker during their archaeological excavations in the Kareng area. C14 dating was done on selected samples by Coulson and Walker and to date, under this project, we have managed to do sulphur, inorganic carbon and organic carbon on all samples. This provides a good indication of palaeo-hydrological conditions.

2.3 NG-02 samples

Samples collected from NG-02 had already been analysed for geochemical analyses and diatoms under an earlier project (Huntsman-Mapila et al., 2006) The profile had also been dated using C14 and luminescence techniques. Therefore, it was decided to continue work on this profile which had yielded some interesting results, by doing both pollen and stable isotopes under this START project. The samples for pollen were done at the University of Missouri-Rolla in the USA by Dr. Francisca Oboh-Ikuenobe. The stable isotopes were done by Dr. Elliot Atekwana, also of the University of Missouri-Rolla.

2.4 Archeological survey

In July 2006, a field trip was organized to visit the archaeological sites of Kareng Square IV, V and VI. This site visit was led by Prof. Sheila Coulson who had conducted the earlier archaeological surveys and allowed other members of the team to put the samples into the right field context. Also present on the field trip was a 3rd year undergraduate student from the University of Botswana who conducted a preliminary field investigation of potential archaeological sites around Lake Ngami during the months of June and July.

3. Results

3.1 KNG-01

Four KNG-01 samples were sent for OSL dating. To date, we have results for two of the samples, one at the bottom of the pit and a second one from 100 cm depth. We expect the last two dates this month. The sample from the bottom of the pit was dated to 162 927 +/- 21 330 yrs BP and the sample from 100 cm depth at 13 173 +/- 1 716 yrs BP. It is interesting to note that the sample from the bottom of the pit contains gastropods species not found throughout the rest of the profile. Most of the gastropods found in the KNG-01 pit represent gastropods found in lacustrine conditions, however, the species found at the bottom of the pit, is a member of the succineidae family which suggests conditions like the modern day Panhandle of the Okavango Delta , which is a fast flowing river (Ramaphane, 2005).

The LOI (550) represents the organic carbon fraction in the sample and generally, a low value suggests dry conditions, where organic matter is not preserved and high values suggest wet conditions where organic matter is preserved. The LOI (950) represents the inorganic carbon fraction of the sample and a low value suggests wet, non-saline conditions and a high value suggest dry conditions if the calcrete is authigenic. The Sulphur (S) is a good indication of redox

condions, with high values suggesting anaerobic and wet conditions in the lake basin and low values suggesting aerobic or dry conditions.

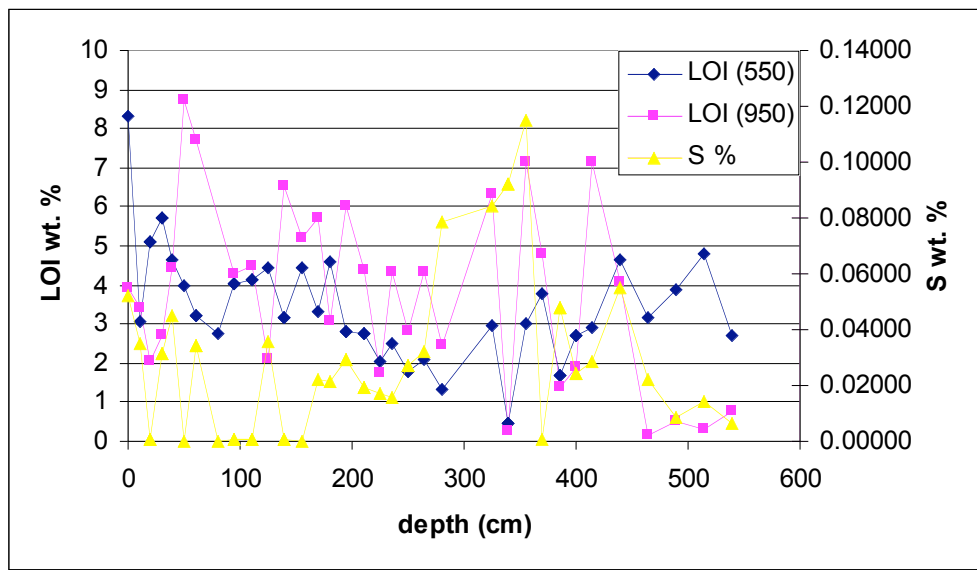


Figure 3. Plots of LOI(550), LOI (950) and S versus depth for KNG-01 samples

Results suggest that lake levels were probably fairly high at depths of 50 cm, 140 cm, 195 cm, 355 and 420 cm. Dates are needed to be able to convert these depths into time periods when lake levels were high. In addition, the results of the trace metals conducted by ICP-MS on the samples will confirm these results.

3.2 Pollen study

Twelve samples were processed for their palynological contents using the standard process of mineral acid digestion. In the samples, more than 200 specimens were counted and these were dominated by a few taxa. Palynological data from sediments can provide useful information about the vegetation in the vicinity of the lake, preservation of organic matter, and lake water levels. For the Lake Ngami samples from pit NG-02, terrigenous components such as phytoclasts and sporomorphs (spores and pollen) dominate the lake sediments; and autochthonous components (i.e., algae and amorphous organic matter) constitute less than 15% of the total counts in all the sediments. Twenty-three groups of pollen and spores, eight types of aquatic algae, copepod eggs, unidentified/indeterminate palynomorphs, and reworked palynomorphs were identified (Oboh-lkuenobe, 2005).

The interval NG02T180 to NG02T410, represents a wetter phase in the lake history with the predominance of species of the freshwater alga *Botryococcus*. This would suggest therefore that, the lake level was high. The higher percentages of black debris (which appear to be black wood fragments) in the sediments also suggest the possibility of recycling, since the opaque nature of the components is attributed to oxidation. Samples from the bottom part of the lake (NG02T440) and the interval NG02T40 to NG02T110 suggest that the lake level was lower or oscillating. Poaceae, which is common in more open vegetation, predominates the assemblage and occurs

alongside *Pediastrum*, *Sparganium*, Cyperaceae, inaperturate pollen, etc. *Pediastrum* is a more salt-tolerant alga than *Botryococcus*, and is considered freshwater to brackish in habit. This suggests that the interval NG-02T40 to NG02T110 represented a more brackish phase in the lake history (Oboh-lkuenobe, 2005).

3.3 Archaeological survey

In June, 2006, an undergraduate student from the University of Botswana conducted a walking archaeological survey near Bodibeng which is located on the southern shore of Lake Ngami. This site was chosen as it is currently being used as a quarry for gravel and previous visits to the site we had encountered various stone artifacts. In her report (Mopako, 2006), Mopako reports that the Bodibeng area is mostly covered with outcrops of quartz and silcretized sandstone. As a result most of the findings have been stone tools, suggesting that human beings exploited the readily available natural resources to meet their needs. Though quartz is one of the most prevalent rock types in the area, few tools recorded have been made from it. Most identified stone tools from the area were made from sandstone. From the tools identified, it has shown that different materials were used for the production of different tools. These tools vary in shape, size, workmanship and appearance. From their characteristics, most of them could possibly be assigned to the Middle Stone Age period.

The site visit to Bodibeng with Prof. Couslon in July 2006 confirmed the significance of this site. However, in addition to finding Middle and Late Stone Age artifacts, as reported by Mopako, Early Stone Age artifacts were also found. This confirms the huge significance of the Lake Ngami basin to early man living in the region. However, these artefacts had been uncovered during gravel quarrying operations and were now strewn about on the surface, with diagnostic specimens from archaeological periods that are hundreds of thousands of years apart being found jumbled together. More work, including a proper excavation of this site is recommended.

4. Discussion and conclusions

The discovery during this project of ESA, MSA, LSA sites all in the vicinity of Lake Ngami, confirm significance of this palaeo-lake for early habitants around the lake basin. Lake Ngami is situated in a semi-arid region, however, inflow to the lake is a result of both local rainfall and rainfall from the catchment area in Angola. Huntsman-Mapila et al., 2006 showed that the lake may have been full during cold and dry periods in central southern Africa, and this may have led to stone age people moving to the lake area. In addition, most of the region is covered with meters of Kalahari sand with very few outcrops. The presence of sandstone and silcrete outcrops along the faultscarp on the southern shore of Lake Ngami and the availability of water resources, meant that this was an ideal habitat for stone age people.

The ESA, MSA and LSA artifacts found near Bodibeng had been brought to the surface because of small-scale quarry activity. Therefore it will be impossible to date these samples as they were not found in situ. To date at this site, only surface surveys were done. However, future excavations, away from disturbed sites will allow for identification and proper dating of artifacts.

Work still needs to be done once we receive the final two OSL dates from KNG-01 to establish a chronology of wet and dry events in the basin dating back as far as 160 ka which is during the MSA. We hope also still to be able to conduct U/Th dating on the gastropods from this profile.

The identification of succineidae family gastropods from the sediment dated to ca. 160 ka BP indicates that at this time fluvial, as opposed to lacustrine conditions predominated. This does not occur at any other time throughout the profile which extends at least until the early Holocene.

Once the chronology of the KNG-01 profile is complete, with the OSL and U/Th dates, it is our intention to present this work at the INQUA Congress to be held in Australia in 2007.

5. Capacity building

In 2005, a 3rd year Archaeology and Environmental Sciences joint major from the University of Botswana worked with us on this project, working on the sediment sample analysis of the KNG-01 samples. In addition, this student worked on the identification of the gastropods found in the KNG-01 samples. In 2006, a 3rd year Archaeology undergraduate from the University of Botswana and the principal investigator had the opportunity to work with Prof. Sheila Coulson, who is currently undertaking an archeological survey in the Lake Ngami Basin. This was extremely enlightening for all parties involved as Prof. Coulson also had some questions concerning where stone age people living around the Kareng area may have sourced the stone material from. A site visit to Bodibeng by the team was able to answer these questions.

Through this project, we were able to employ a graduate from the Environmental Sciences Department of the University of Botswana and a high school graduate from Maun Senior Secondary School. Both were trained in the HOORC environmental laboratory in techniques applicable to palaeo-environmental reconstructions. Both have been able to continue their work in the laboratory as they have been taken on by other projects.

6. Lessons learnt

- 1) from this project we have learnt how difficult it is to obtain a reliable chronology on the profiles. We are still awaiting 2 more OSL dates for KNG-01 but 4 dates are not sufficient for this profile. We had intended to use U/Th dating of gastropods but we have not yet identified a laboratory willing to do this work. We may be able to use C14 for the top part of the profile but the limit for C14 dating is about 48 ka and our entire profile is about 160 ka. I would advise other researchers who are interested in conducting palaeo-environmental reconstructions to carefully consider what dating techniques can be used for their work otherwise you may end up with palaeo-environmental events which are not well constrained.
- 2) In addition, we have learnt that for palaeo-environmental reconstructions, it is much more informative to do a multi-proxy study as each of the different proxies used for palaeo-environmental reconstructions have their own limitations. Therefore, by applying as many different techniques as possible, ie geochemistry, pollens, diatoms, one can do a more reliable study.

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