Inter-disciplinary Discussion

Discussion on the Last Glacial Maximum in southern Africa

Jennifer M. Fitchett[1], Jasper Knight[1], Marion K. Bamford[2,3], Hayley Cawthra[4], Amanda Esterhuysen[1], Lynne J. Quick[5] & J. Francis Thackeray[2,3]

[1]*School of Geography, Archaeology and Environmental Studies, University of the Witwatersrand*
[2]*Evolutionary Studies Institute, University of the Witwatersrand*
[3]*School of Geosciences, University of the Witwatersrand*
[4]*Council for Geoscience*
[5]*Department of Environmental and Geographical Science, University of Cape Town*

Introduction

During the 21st Biennial Conference of the Southern African Society for Quaternary Research (SASQUA; April 2017), a panel debate was convened to discuss the state of science pertaining to the Last Glacial Maximum (LGM) in southern Africa. From a global perspective the LGM corresponds to the coldest phase of the last glacial cycle, and is a critical period to focus on as palaeoenvironmental data from this period allow for a better understanding of how large-scale climatic forcings translate to local and regional environments. Reconstructions of climatic conditions (temperature, moisture availability and seasonality) for this period are also essential for the robust evaluation of climate models. In southern Africa, key questions pertaining to the LGM period included the timing of the event as a whole and its coldest conditions, the overall climatic conditions during this period, the varied palaeoenvironmental evidence for the event, and the microscale geographic variation in palaeoenvironmental conditions. These questions are particularly pertinent in a southern African context, given the absence of undisputed glacial or periglacial evidence for the LGM. The aim of the panel debate was to discuss the context and significance of existing knowledge, and the pertinent avenues for future research in the region, into the Quaternary period generally and the LGM in particular. The panel comprised representatives from some of the key subdisciplines of southern African Quaternary science: archaeology (Prof. Amanda Esterhuysen), geology (Dr Hayley Cawthra), palaeoecology (Dr Lynne Quick), and palaeoanthropology and palaeoecology (Prof. Francis Thackeray). The panel was chaired by Prof. Jasper Knight, and convened by Dr Jennifer Fitchett and Prof. Marion Bamford. The debate was opened to the floor for interaction from the broader southern African palaeoscience community, as represented by SASQUA conference delegates.

Timing and climatic conditions of the LGM

Although a topic of contention across the southern hemisphere as a whole (*cf.* Petherick *et al.* 2016), the panel did not explicitly contest the conventional notion of the LGM in southern Africa at ~21 000 cal yr BP. It should be noted, however, that in most instances this timing was derived by a temporary absence of data, rather than positive evidence derived from different records. The absence of data across a number of proxies over the broad period 24 000–20 000 cal yr BP is interpreted to have resulted in part from the particularly cold climatic conditions at this time, suppressing the behaviour of surface river, soil and ecosystems, and inhibiting fossil preservation. The overlap in these periods of poor proxy record availability for a number of sites and for a range of proxies is notable, yet the absence of positive proxy evidence does preclude the inference of climatic conditions during the LGM, such as from regional lake or marine records.

Existing proxy data, from which palaeoclimatic and palaeoenvironmental reconstructions have been made for the LGM period, vary in their degree of predictive strength. Proxies such as isotopes have the capacity to quantitatively reconstruct past moisture and temperature regimes, but issues of isotopic contamination/overprinting are difficult to resolve and transfer functions may be subject to error and there is an absence of training sets. Most proxy evidence for the LGM period itself is derived either from sediment cores or archaeological sites, often requiring the interpretation of climatic conditions on the basis of regional vegetation change from pollen data and faunal assemblages from these sites. In order to make these somewhat qualitative inferences of past climate from plant fossil records more robust, reliance has been placed on statistical methods. While simple methods of factor analysis and principal components analysis can elucidate broad gradients in palaeoenvironmental data, they can seldom accurately decouple the moisture and temperature records or distinguish these from other local environmental factors. Where moisture records can be isolated, it becomes difficult to determine the relative importance of precipitation, evaporation and the seasonality of precipitation. More complex statistical approaches have been recently proposed (*cf.* Chevalier *et al.* 2014), but there remains concern regarding the extent to which these can be applied to a broader range of locations and depositional environments, and the suitability in what are likely non-analogous conditions during the LGM. There was consensus among the panellists that any statistical approaches should be undertaken by experts with in-depth knowledge of both the proxy utilized, and the contemporary environment from which it was derived. Caution was raised, however, regarding an over-reliance on comparisons with the present, given both the magnitude of temperature departures during the LGM, the potential for non-analogous conditions during the LGM, and the rapid rate of contemporary climate change.

Palaeoclimatic evidence from southern Africa encompassing the LGM period consistently indicates an average temperature depression of >6°C, yet the precise value and land surface impact of this depression remains uncertain both spatially and temporally, as evaluated from different proxies. Moisture records are more clearly defined, yet indicate considerable spatial heterogeneity, including a moisture dipole within the contemporary winter rainfall zone. This moisture variability is posited to result from the increased influence of the southern westerlies during the LGM. However, there remain many outstanding questions relating to the dynamics and interactions of the temperate climate systems (the westerlies) and tropical moisture sources, and how these systems have influenced rainfall regimes across southern Africa during and since the LGM. Exploring climatic conditions leading into and out of the LGM was highlighted as a means to better understand why there are spatial and temporal variations in response, and why the LGM may be recorded differently based on different proxies.

Avenues for Future Research

An important component of the discussion was the identification of sites for targeted and integrated (multidisciplinary) research on the LGM. The Quaternary science research transects proposed by Chase & Meadows (2007), extending north, northeast and east of the WRZ, were raised as an important starting point, and there was consensus that these reflected regions of importance in better understanding climate variability throughout the LGM. However, it was noted that few palaeoenvironmental records exist in large areas of southern Africa, mainly due to low preservation potential. LGM-age material is commonly available at known archaeological sites, yet these have not been studied in great detail as the period does not reflect technological or cultural innovation periods of interest to archaeologists. It was thus proposed that research should endeavour to integrate the approaches of a range of Quaternary palaeosciences at these archaeological sites, to obtain fossil proxy evidence for the climates and environments of the LGM. There is also some debate about the timing and degree of sea-level changes, particularly in relation to coastal sites (Cawthra *et al.* 2016), but there is uncertainty on the extent to which these independent data can be correlated with other coastal sites or to inland sites.

It was concluded by panellists and SASQUA participants that while there is undoubtedly a clear need for continued research to refine our understanding of the timing and climate of the LGM, it is also important to revisit, re-date and reanalyse past datasets, in particular from key sites.

Acknowledgements

The SASQUA 2017 Conference, and J.F. and M.B. personally, were supported by funding from the DST/NRF Centre for Excellence in Palaeosciences.

References

CAWTHRA, H.C., COMPTON, J.S., FISHER, E.C., MACHUTCHON, M.R. & MAREAN, C.W. 2016. Submerged shorelines and landscape features offshore of Mossel Bay, South Africa. **In**: Harff, J., Bailey, G. & Lüth, F. (eds), *Geology and Archaeology: Submerged Landscapes of the Continental Shelf*, 219–233. London, Geological Society, Special Publications, **411**.

CHASE, B.M. & MEADOWS, M.E. 2007. Late Quaternary dynamics of southern Africa's winter rainfall zone. *Earth-Science Reviews* **84**(3), 103–138.

CHEVALIER, M., CHEDDADI, R. & CHASE, B.M. 2014. CREST (Climate REconstruction SofTware): a probability density function (PDF)-based quantitative climate reconstruction method. *Climate of the Past* **10**, 2081–2098.

PETHERICK, L., SHULMEISTER, J., KNIGHT, J. & ROJAS, M. 2016. SHeMax: the Last Glacial Maximum in the southern hemisphere. *Quaternary Australasia* **33**(2), 32–34.