AEGC2019 Data to Discovery
Australasian Exploration Geoscience Conference
2-5 September 2019 • Perth, Western Australia
Incorporating the AIG, ASEG, PESA, and WABS

Sea level controls on buried geomorphology within the Swan River estuary during the Late Quaternary

Giada Bufarale*
Curtin University
Bentley, WA 6102
giada.bufarale@gmail.com

Mick O'Leary
UWA / Curtin University
35 Stirling Hwy, Crawley, WA 6009
mick.oleary@uwa.edu.au

Alexandra Stevens
Curtin University
Bentley, WA 6102
m.a.stevens@curtin.edu.au

SUMMARY

A high-resolution seismic survey was carried out across the metropolitan reach of the Swan River (Perth, Western Australia) to investigate its Late Quaternary sub-surficial geomorphology. Shallow imaging data, integrated with sediment cores, pre-existing literature (including dating) and LiDAR images, revealed three main units, forming a complex system of buried paleochannels, which developed during the Late Quaternary glacial sea level lowstands, and infilled during interglacial highstands.

The deepest unit was interpreted as comprising estuarine to fluvial sediments of the Perth Formation, deposited during the Last Interglacial (~130-80 thousand years before present) in a wide paleo-valley that cut the basement.

The sedimentary sequence of the overlaying middle unit belongs to the Swan River Formation, which consists of heterogenic fluvial to lacustrine sediments, deposited during the Last Glacial lowstand (~80-18 thousand years before present).

The shallowest unit comprises Holocene fluvial and estuarine sediments, up to ten-thousand-year-old.

This research represents the first environmental high-resolution acoustic investigation of the Swan River estuary. The findings have improved the understanding of the Late Quaternary Swan River development, providing a useful tool for modelling river onset and evolution, following sea level transgressions.

Key words: sea level fluctuations, high-resolution seismic stratigraphy, Swan River paleochannels, Late Quaternary.

INTRODUCTION

Late Pleistocene and Holocene Epochs (spanning from ~130 ky to present) have been distinguished by several orbitally-driven changes in sea level. This period captured the peak of the Last Interglacial (Marine Isotope Stage MIS 5e; 127 to 116 ky) with sea levels between 3 and 6 metres above present. The stage between 110 ky and 80 ky saw sea level oscillating between -10 and -30 metres below present (MIS 5d, c, b and a). After 40 ky, global cooling saw sea levels fall to around -125 m at the Last Glacial Maximum (LGM), which peaked around 18 ky years BP. The global deglaciation, following the LGM, was characterised by rapidly rising sea levels reaching near present elevations around 7 ky BP (see Bufarale et al., 2017 for full list of references).

This study aimed to construct a more detailed picture of Late Quaternary sequence stratigraphy and sedimentary architecture of the metropolitan Swan River (Perth, Western Australia), to better understand how changing sea level driven fluctuations (base level) have influenced the evolution of the estuary throughout this period.

METHOD AND RESULTS

Approximately 30 km of high-resolution shallow seismic profiles were collected using a boomer-sub bottom profiler system along the Swan River estuary, between the Narrows Bridge and Blackwall Reach (Figure 1, top). Survey lines were devised to capture a range of substrate architectures and geometries, to a maximum depth of 40 m below the riverbed.

The processed acoustic profiles revealed a complex system of paleochannels where three main unconformities (R1, R2 and R3) bound as many seismic units (U1, U2, U3), over the acoustic basement (Figure 1, bottom).

Integrating these data with sediment borehole analyses, LiDAR (Light Detection and Ranging) images and the available literature of the geology and chrono-stratigraphy of the area, it was possible to determine the development of these units (Figure 2).

Since no dating has been undertaken for this research, the following interpretation was performed using pre-existing literature, including Wallace and Kimber (1989); Kendrick et al. (1991); Gozzard (2007); Brooke (2010) and Mathew (2010).

Results and Discussion

The deepest unit (U3) is interpreted as the Perth Formation, which consists of ~20 m thick interbedded, fluvial to estuarine sediments that were deposited in a large paleo-valley that incised into the underlying acoustic basement (bedrock: Tamala Limestone and Kings Park Formation). This period spans ~130-80 thousand years before present (BP) in the Last Interglacial (correlating this formation to the sediments dated by Murray-Wallace and Kimber (1989) and Kendrick et al. (1991)).

The Perth Formation is overlain by a ~27 m thick unit (U2), composed of heterogenic fluvial to lacustrine sediments, belonging to the Swan River Formation (Gozzard, 2007). Similar to U3, U2 also infills channels incised in older deposits and reflects the hydrogeological conditions linked with sea level changes during the Last Glacial lowstand.

Holocene (last ~10 ky) fluvial and estuarine deposits form the shallowest unit (U1). These sediments are up to 14 m thick and have a highly variable internal structure, ranging from layered to chaotic deposits. The Holocene sediments are also found filling paleochannels and blanketing the pre-existing topography.

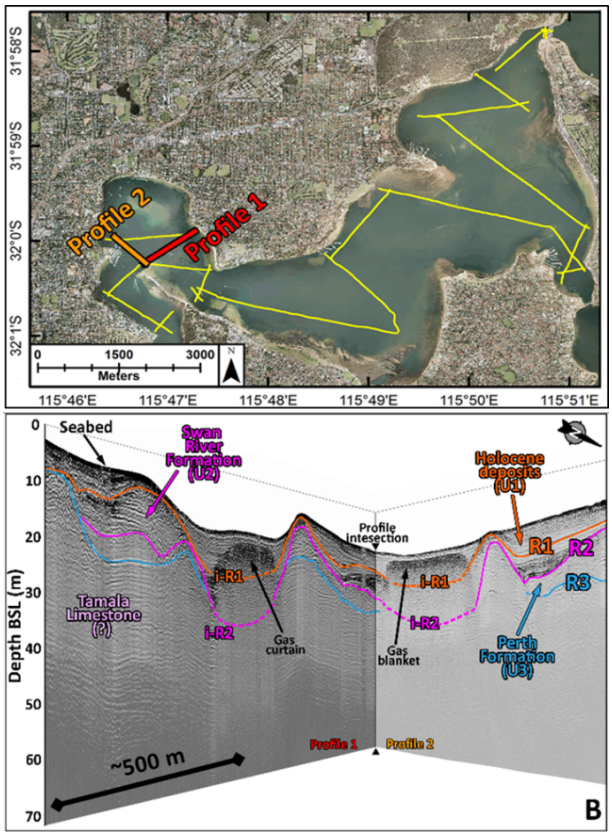

Figure 1. Top: Locality map showing the study area. Seismic survey track plot is marked, in yellow. Bottom: Intersecting seismic cross section showing the buried geology described in the text. Length of profile 1: ~ 1000 m; length of profile 2: ~650 m.

CONCLUSIONS

This research describes new insights resulting from the first environmental high-resolution seismic investigation in the metropolitan reach of the Swan River estuary.

The data indicated that sea level-driven changes in base level and the influence this latter had on fluvial sediment dynamics played a major role in controlling the development of the Swan River during the Late Quaternary. Throughout this geological time, paleochannels developed in glacial low sea level stands, and have been filled by sediments, during interglacial highstands. Pre-existing topography has shaped and influenced successive morphological features, as well.

A fuller account of this work can be found in Bufarale et al. (2017).

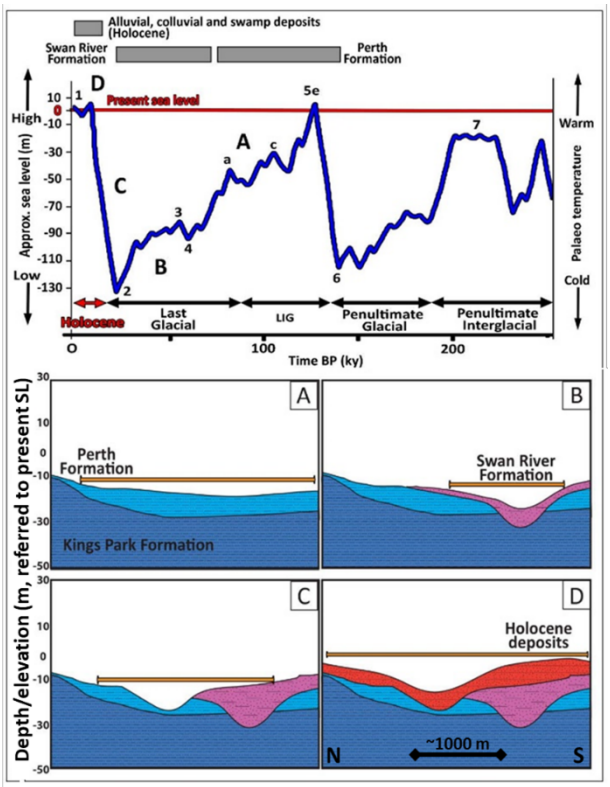

Figure 2. Top: Sea level curve in the past 250 ky. Odd numbers refer to Interglacial Marine Isotope Stages (MIS) and even numbers indicate the Glacial MIS. Modified after Lisiecki and Raymo (2005); Berger (2008) and Saqab and Bourget (2015). Bottom: Schematic cross-section showing the evolution of the morpho-stratigraphy in the metropolitan reach of the Swan River through the Late Quaternary (approximately from Perth CBD to South Perth), based on seismic profiles and Gozzard (2007). Horizontal axis: ~ 3 km, orientation N-S; vertical axis: depth/elevation values are in metres, referred to the present sea level. Orange lines represent the width of active valley. A) During the Last Glacial period, a deep inset valley cut the pre-existing Kings Park Formation and Perth Formation, during a low sea level stand. B) Changes in sea level caused by fluctuations in the climate during the last 50-70 ky of this Glacial period resulted in an alternation of erosion and deposition during which the paleochannel was filled with the variegate sediments of the Swan River Formation. C) Last Glacial Maximum (MIS 2, ~ 18 ky BP). As the sea level reached its lowest point, the most recent paleochannel was cut and successively (D) infilled with fluvial deposits through the Holocene interglacial conditions.

ACKNOWLEDGEMENTS

The original form of this research study was carried out as part of a PhD thesis at Curtin University (2014-2018), undertaken by G. Bufarale. The views and material contained in this presentation are those of the first author and co-authors and not those of her current employer. The first author would like to thank the contribution of the Australian Government Research Training Program Scholarship in financially supporting this research; Professor Lindsay Collins and Dr Mick O'Leary for their supervision; and the Swan River Trust for approving the survey and providing the vessel support for marine operation.

REFERENCES

Berger, W.H., 2008. Sea level in the Late Quaternary: Patterns of variation and implications. International Journal of Earth Science 97, pp.1143-1150. doi:10.1007/s00531-008-0343-y.

Brooke, B., Creasey, J. and Sexton, M., 2010. Broad-scale geomorphology and benthic habitats of the Perth coastal plain and Rottnest Shelf, Western Australia, identified in a merged topographic and bathymetric digital relief model. International Journal of Remote Sensing, 31(23), pp.6223-6237.

Bufarale, G., O'Leary, M., Stevens, A. and Collins, L.B., 2017. Sea level controls on paleochannel development within the Swan River estuary during the Late Pleistocene to Holocene. Catena, 153, pp.131-142.

Gozzard, J.R., 2007. The Guildford Formation re-evaluated, Australian Geomechanics Society and Institute of Engineers, 42(3), pp.59-79.

Kendrick, G.W., Wyrwoll, K.-H., Szabo, B.J., 1991. Pliocene–Pleistocene coastal events and history along the western margin of Australia. Quaternary Science Reviews 10(5), pp.419-439.

Lisiecki, L.E., Raymo, M.E., 2005. A Pliocene-Pleistocene stack of 57 globally distributed benthic δ18O records. Paleoceanography 20, pp.1-17. doi:10.1029/2004PA001071.

Mathew, G.V., 2010. Analysis and interpretation of ground and building movements due to EPB tunnelling. PhD Thesis, University of Western Australia.

Murray-Wallace, C. V., Kimber, R.W.L., 1989. Quaternary marine aminostratigraphy: Perth Basin, Western Australia. Australian Journal of Earth Science 36, pp.553-568. doi:10.1080/08120098908729509.

Saqab, M.M., Bourget, J., 2015. Controls on the distribution and growth of isolated carbonate build-ups in the Timor Sea (NW Australia) during the Quaternary. Marine Petroleoum Geololy 62, pp123-143. doi:10.1016/j.marpetgeo.2015.01.014.