The University of Adelaide/NTGS/Industry/Australian Research Council Collaboration – greater McArthur Basin

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This workshop highlights some of the research undertaken by an Australian Research Council-supported Linkage Project (LP200301457) that enabled researchers from The University of Adelaide and collaborators in CSIRO and The University of Copenhagen to partner with the Northern Territory Geological Survey, Santos, Empire Energy, BHP and Teck Resources to better understand the evolution and connectivity of the greater McArthur Basin (Close 2014). This followed on from a previous ARC Linkage project (LP160100479) that also partnered with NTGS, Santos and Empire, but also included Origin Energy. Over the course of the latter phase of the project, we also received financial and in-kind support from OzMinerals and Resolution Minerals. Through Simon Holford, we have also developed a PhD student collaboration with The University of Aberdeen.

The greater McArthur Basin is taken here to include the McArthur Basin *sensu stricto*, the Beetaloo Sub-Basin, the Birrindudu Basin, the Tomkinson Province and the South Nicholson Basin. We divided the project into three main, quite simple and overarching, themes: chronostratigraphy, chemostratigraphy and lithostratigraphy. During the workshop, we will present some of the most recent outcomes in these themes, but for my presentation, I would like to first provide an overview of the project, place the project in the most recent tectono-geographic framework, then highlight a few major outcomes of our team over the last few years.

The greater McArthur Basin of northern Australia is a vast frontier exploration province for basin-hosted resources, both hydrocarbons (oil and natural gas) and metals [critical metals (eg rare earth elements, Co), Cu, Pb, Zn and Au]. This basin system covers much of northern Australia and may have included much of North China that lay off northern Australia when the basin formed at ca 1820–1325 Ma. Hydrocarbon and metal deposits in the basin are largely controlled by host sediment composition and 'redox traps' related to ancient water chemistry, which, in-turn, are modulated by biological activity, tectonism and relative sea level change. None of these controls are fully understood or constrained throughout the basin.

To better understand the evolution of the basin we followed a number of approaches, including:

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1. Developing new techniques to date shales and carbonate rocks, rapidly and economically, to assist with intra-basinal correlation, thermal and hydrothermal overprint history, and to help build a basin chronostratigraphic framework (eg Subarkah *et al* 2021, 2022, 2024).

Innovations in laser mass spectrometry have been used to date shales (Rb–Sr) and carbonate rocks (mapping U–Pb) from the McArthur Basin, and triage the resulting data to separate ages interpreted as dating deposition or early diagenesis, from those reflecting later hydrothermal overprints. These are coupled with campaign-style detrital mineral geochronology and targeted high-precision U–Pb thermal ionisation mass spectrometry to build a basin chronostratigraphy.

2. Characterizing the source areas for the basin system through detrital petrochronology and shale geochemistry (eg Yang *et al* 2022, 2023, Khanna *et al* 2025).

Detrital minerals (zircon, rutile, muscovite) from the main depositional 'packages' (Rawlings 2019) in the greater McArthur Basin have been dated and their trace element compositions determined, in order to build a spatial and temporal database of source material. This has been interpreted based on the tectonic evolution of the basement terranes around the greater McArthur Basin during the amalgamation of the Australian continents within Nuna/Columbia.

3. Investigating the ancient basin water chemistry through chemical proxies that relate to bio-productivity, salinity/restriction, and redox, both temporally and spatially (eg Cox *et al* 2022).

Proterozoic basin waters were extremely heterogeneous in dissolved oxygen. We have been developing and building basin-wide elemental (eg U, V, Cu, Co, Mo, Fe, organic geochemistry) and isotopic (Cr, Cd) proxies for the reconstruction of paleoredox and paleobioproductivity conditions at different sites in the ambient water columns. These will be coupled with elemental and isotopic proxies for restriction/salinity (including coupled $^{87}Sr/^{86}Sr$ and $^{88}Sr/^{86}Sr$ datasets from carbonate rocks) and proxies for biological activity (eg Cr/Cd, as well as C and N isotopes). They are being interpreted in a sequence stratigraphic framework to understand the dynamics between basin water chemistry, tectonics and basin water level variations.

4. Building a reconstruction of the basin, and of the tectonic geography of the basin and its environs through the ca 1.8–1.32 Ga history of its existence (eg Figure 1; Soares *et al* 2025). This has been facilitated by constructing a full-plate tectonic reconstruction for the Proterozoic.

Here we present a full-plate tectonic reconstruction from 1.8 Ga to present, focussed on the region of the Australian continental lithosphere (**Figure 1**). The greater McArthur Basin is considered as part of the McArthur-Yanliao Gulf of Nuna/Columbia and the nature of the basin will be addressed at different times and in different places.

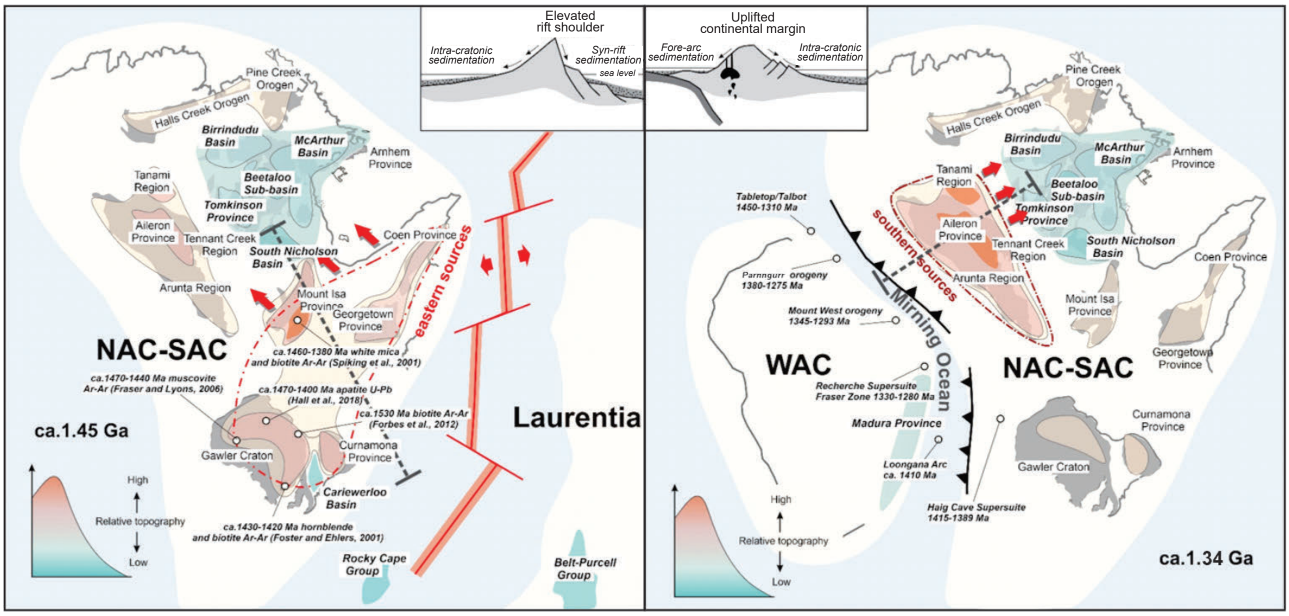

Figure 1. Reconstructed tectonic geography model of the combined North Australia Craton (NAC) and South Australia Craton (SAC) and Western Australia Craton (WAC) at ca 1.45 Ga and ca 1.34 Ga, showing the elevation of the eastern basement terranes during the separation between Proterozoic Australia and Laurentia followed by topography creation to the south as the WAC collided with the combined SAC-NAC during the final stages of Nuna closure (after Yang *et al* 2023).

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