

Integrated precompetitive geoscience transforming understanding of Northern Territory geology

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Regional geoscience projects, together with the integration of new regional scale precompetitive datasets acquired under the 2014–2018 *Creating Opportunities for Resource Exploration (CORE)* initiative, have transformed the knowledge of the geology of the Northern Territory in key areas. Collaboration with Geoscience Australia under the federally funded 2016–2020 *Exploring for the Future* program (Blewett 2018) will continue to provide foundation datasets in underexplored areas of the Northern Territory.

Integrated precompetitive geoscience approach for the greater McArthur Basin

The acquisition of 4 km spaced or better ground gravity and 400 m line spacing of airborne magnetic and radiometric data (potential field data) over the greater McArthur Basin was a focus of the *CORE* initiative (Dhu and Hallett 2017). This foundation dataset has been a key tool to improve the understanding to the structural architecture of the Palaeo-Mesoproterozoic basin successions and the composition of the underlying metamorphosed basement. The upgraded regional scale potential field data plus the recently acquired 2 km spaced ground gravity over the Batten Fault Zone (Dhu 2018) is being used to model sub-basin architecture in the Palaeoproterozoic McArthur Group of the McArthur Basin (Blaikie and Kunzmann 2018). Understanding the architecture and structural controls at this scale is providing the framework for studying the depositional environment of the middle McArthur Group within these sub-basins (Kunzmann *et al* 2018), an example being the setting of the Teena Pb-Zn deposit (Taylor and Hayward 2016). An analysis of the lithologies of the middle McArthur Group through high-resolution descriptive logging of open file drill core within the Glyde sub-basin (Kunzmann *et al* 2017) has allowed a sequence stratigraphic approach to understanding lateral facies variations at this sub-basin scale. This detailed understanding of the depositional environment within a discrete sub-basin also forms the basis to investigate carbon isotopes as a tool for stratigraphic correlation (Kunzmann *et al* 2018).

The structural architecture of the sub-basin development and corresponding depositional fill has provided key information to assist in modelling the mechanisms that influence fluid flow in mineral systems within the fertile Batten Fault Zone (Sheldon and Schaub 2018).

A systematic approach to characterising each formation within the Palaeo–Mesoproterozoic stratigraphy of the greater McArthur Basin has provided a foundation dataset for intra-basinal stratigraphic correlations and provenance patterns. Type sections for each formation (where the upper and lower stratigraphic contacts are identified) in the Wilton package and Glyde package across the greater McArthur Basin were field checked, described and sampled

for thin section production, multi-element whole rock geochemistry, and U–Pb detrital zircon and Lu–Hf isotope analyses (Kositcin *et al* 2017, Munson *et al* in review). This work has assisted in correlating Mesoproterozoic stratigraphy across the outcropping units in the McArthur, Birrindudu basins and Tomkinson Province (Munson 2016a,b). The results support the seismic evidence (Hoffman 2014, Hoffmann 2015) that these units represent a connected depositional basin.

Whilst U–Pb detrital zircon geochronology provides robust and comparable maximum deposition ages, an Australian Research Council Linkage project co-ordinated through University of Adelaide will investigate alternative isotopic approaches to assess depositional environments and improved age constraints for the stratigraphy in the basin (Collins *et al* 2018).

The improved resolution of the regional scale potential field datasets was key to updating the SEEBASE® product for the greater McArthur Basin (Frogtech Geoscience). The incorporation of this potential field data and upgraded industry seismic data (Dhu 2018) significantly contributed to an improved definition of the extent and subsurface thickness of the Mesoproterozoic Roper Group stratigraphy in the SEEBASE product and to the definition of the concealed Beetaloo Sub-basin boundary (Williams in prep).

Field work in the Arnhem Province on new 1:100 000 scale, outcrop geology maps (Kraus *et al* 2015, Whelan *et al* 2017) has provided isotopic evidence that the fragments of ‘basement’ exposure on the eastern margin of the greater McArthur Basin comprise age correlatives of the Pine Creek Orogen (forming part of the North Australian Craton). Whelan *et al* 2017 suggest that the whole rock Nd and zircon Hf–O isotopic evidence from (meta)igneous units in west and east Arnhem Land is indistinguishable, which indicates there is no difference in the crust beneath these basement terranes. The updated SEEBASE product incorporated this interpretation and suggested the greater McArthur Basin overlies a series of crustal elements with rheological contrast that influence basin/s formation and evolution (Connors and Pryor 2018).

Integrated precompetitive geoscience approach for the Aileron Province

Detailed investigations into the structural, metamorphic, magmatic, and depositional evolution of the eastern Aileron Province, conducted as part of the 1:100 000 mapping program (Reno *et al* 2015, Weisheit *et al* 2016, Reno *et al* 2017), has provided context to understanding the base metal mineral systems operating in this area. The well-exposed base metal mineralisation at the Jervois mineral field provided the opportunity to characterise the mineral systems in relation to the evolving regional geology. Syn-sedimentary Cu–Ag–Pb–Zn mineralisation is associated with high-thermal gradient metamorphism and bimodal magmatism in a back-arc basin setting at 1.79 Ga (McGloin

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and Weisheit 2015, Reno *et al* 2017). The identification of metaexhalites as indicators of the alteration process during mineralisation in this setting, and thereby representing a potential vectoring tool, has been an important finding from this project (McGloin 2017). McGloin (2017) has differentiated epigenetic Cu-bearing mineralisation characterised by magnetite-chlorite alteration at the Jervois mineral field, particularly at the Rockface deposit, and at other prospects in the Aileron Province (eg Johnnies Reward).

Integrated precompetitive geoscience approach for the Amadeus Basin

The characterisation and redefinition of the Neoproterozoic stratigraphy of the Amadeus Basin (Donnellan and Normington 2017) has provided the basis to revise the distribution of outcropping geology on the Henbury 1:250 000 mapsheet. The improved understanding of the Neoproterozoic history of the Amadeus Basin is ensuring basin-wide correlations of units currently targeted for conventional petroleum plays.

Construction of a pre-Mesozoic 1:500 000 basin-wide interpreted geology map for the Amadeus Basin (Weisheit and Donnellan 2018) will assist in the correlation of concealed stratigraphic units and the interpretation of subtle formation parallel structures. Integration of this seamless interpreted geology with the extensive industry acquired 2D seismic data will allow the construction of a 3D model of the basin and provide a framework of basin architecture for future petroleum and mineral system studies.

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