

Towards an improved understanding of the 3D structural architecture of the greater McArthur Basin through geophysical interpretation and modelling

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Project overview

This project is part of a 3 year collaborative agreement between CSIRO Mineral Resources and Northern Territory Geological Survey (NTGS) that is designed to improve the understanding of the geology and the processes controlling mineralisation and prospectivity of the greater McArthur Basin.

The research focuses on increasing the knowledge of the 3D architecture of the Basin through geologically constrained interpretation and modelling of geophysical data. The study will focus on key areas within the Basin, including the Batten Fault Zone, Walker Fault Zone and Beetaloo Sub-basin (**Figure 1**). Analysis and interpretation of gravity, magnetics, radiometrics, airborne electromagnetic (AEM), and seismic data will be coupled with 2D and 3D modelling of the gravity and magnetic data. The objective is to constrain the 3D distribution and structural controls of the stacked depositional packages within the Basin, and to determine how each package evolved within the tectonic framework of the North Australian Craton.

Preliminary results from the interpretation of geophysical data across the Batten Fault Zone presented herein include structural and lithological interpretations. These interpretations will provide the constraints for future work constructing 2D and 3D geophysical models. These models will improve the current understanding of the subsurface architecture of the Batten Fault Zone, and in particular that of sub-basin development within the McArthur Group.

Introduction

An improved understanding of the geology and tectonic evolution of the greater McArthur Basin requires knowledge of major structures, their kinematics, and the spatial distribution of depositional packages in 3D. Significant areas of the greater McArthur Basin are masked by cover and require geophysical interpretation and modelling to understand structures and stratigraphy at depth. Regional geophysical datasets can image the 3D geometry of subsurface geology even in areas of poor exposure. When combined with geological observations, geophysical interpretation and modelling can provide constraints on geological evolution that otherwise could not be resolved purely through surface observation.

A geophysical interpretation produced by Betts *et al* (2015) identified major structural features and the spatial distribution of the depositional packages across the greater McArthur Basin. Since that interpretation was completed, higher resolution geophysical datasets were acquired over much of the basin under the *Creating Opportunities for*

Resource Exploration (CORE) initiative (Dhu 2016). The higher resolution datasets provide greater clarity of both the major structures and the overprinting relationships of the region.

This project will refine the structural interpretation produced by Betts *et al* (2015) through interpretation of recently acquired geophysical datasets. The objective is to define the 3D basin architecture through lithologically constrained 2D and 3D potential field modelling.

Regional geology

The Palaeo–Mesoproterozoic greater McArthur Basin, as defined in Close (2014), comprises sedimentary and volcanic rocks from five stacked and superimposed depositional sequences (**Figure 1**) that developed over a period of approximately 400 million years (Ahmad *et al* 2013, Rawlings 1999). In the Northern Territory, the greater McArthur Basin extends west under cover connecting with the Beetaloo Sub-basin and Birrindudu Basin; it is likely continuous with the Tomkinson Province towards the south. Rawlings (1999) defined five major depositional packages within the McArthur Basin: Wilton, Favenc, Glyde, Goyder and Redbank. Each package is separated by major unconformities associated with inversion events. These packages can be correlated with the Leichhardt, Calvert, Isa and South Nicholson super-basins in Queensland (Jackson *et al* 2000).

Two north-trending fault zones are recognised within the McArthur Basin: the Batten and Walker fault zones. These are separated by the east-trending Urapunga Fault Zone (**Figure 1**; Ahmad *et al* 2013). The Batten Fault Zone is a 50–80 km wide fault zone located in south-eastern McArthur Basin. It is notable as it hosts the world class Zn-Pb deposit at the McArthur River Mine. This fault zone exposes four of the five major depositional packages (Redbank, Glyde, Favenc and Wilton) and provides an opportunity to understand the architecture and relationship between these units. Knowledge gained here, particularly relating to the orientation of structures controlling sub-basin development in the McArthur Group, can be applied to constrain modelling elsewhere, such as the Beetaloo Sub-basin where there is currently no constraint on the architecture of the Glyde package.

Geophysical interpretation of the Batten Fault Zone

To date, the interpretation on the distribution of individual formations has focused on the Batten Fault Zone. The structural and lithological interpretation, currently covering the BAUHINIA DOWNS and MOUNT YOUNG 1:250 000 mapsheets⁴ (**Figure 2**), was based upon the interpretation of gravity, magnetic, radiometric, and AEM datasets; and

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⁴ Names of 1:250 000 mapsheets are shown in capital letters, eg BAUHINIA DOWNS.

constrained by geological mapping, drillholes and satellite photos. The geophysical characteristics of the Wilton, Glyde and Redbank packages are described below.

Wilton package – Roper Group

The Wilton package is largely confined to the west of the Batten Fault Zone and to the east of the Emu Fault. The package is characterised by a low gravity and magnetic response. The magnetic data often contains short to long wavelength features associated with volcanic intrusions into the Wilton package. Individual formations within the Wilton package can be resolved through enhancement of short-wavelength features (vertical and tilt derivatives) in the magnetic data, and interpretation of the radiometric data. Some of the oldest units of the Wilton package, ie the Mantungula to Crawford formations, have a K-enriched signal; other formations including and above the Abner Sandstone tend to have a more Th-enriched response; and some shales (eg Corcoran and Velkerri formations) have a U-enriched signal.

Glyde package–McArthur Group

In contrast to the Roper Group, the McArthur Group contains more carbonate sequences and therefore has a higher density. The McArthur Group is resolvable in the

regional geophysical data as a prominent north–south trending gravity high. In higher resolution gravity surveys (minimum of 500 m station spacing), the distribution of different formations can be resolved because density is variable through the stratigraphy. This package has low magnetic response; however, volcanics in the underlying Tawallah Group have a high magnetic susceptibility and therefore interpretation of the magnetic data (depth to magnetic basement inversion) may provide constraint on the thickness of the McArthur Group. The radiometric data shows that the McArthur Group has a K-enriched signal.

Redbank package – Tawallah Group

Outcrop of the Tawallah Group is largely confined to the northern half of the Batten Fault Zone. This Group is defined by a low gravity anomaly and a high magnetic response where volcanics are present; and by a low gravity and magnetic response where sandstones are present. The radiometric data shows that the sandstone formations are more Th-enriched; the volcanics tend to have a K-enriched radiometric signal.

Structural features

The Batten Fault Zone is characterised by north–south trending strike-slip and thrust faults. These faults were

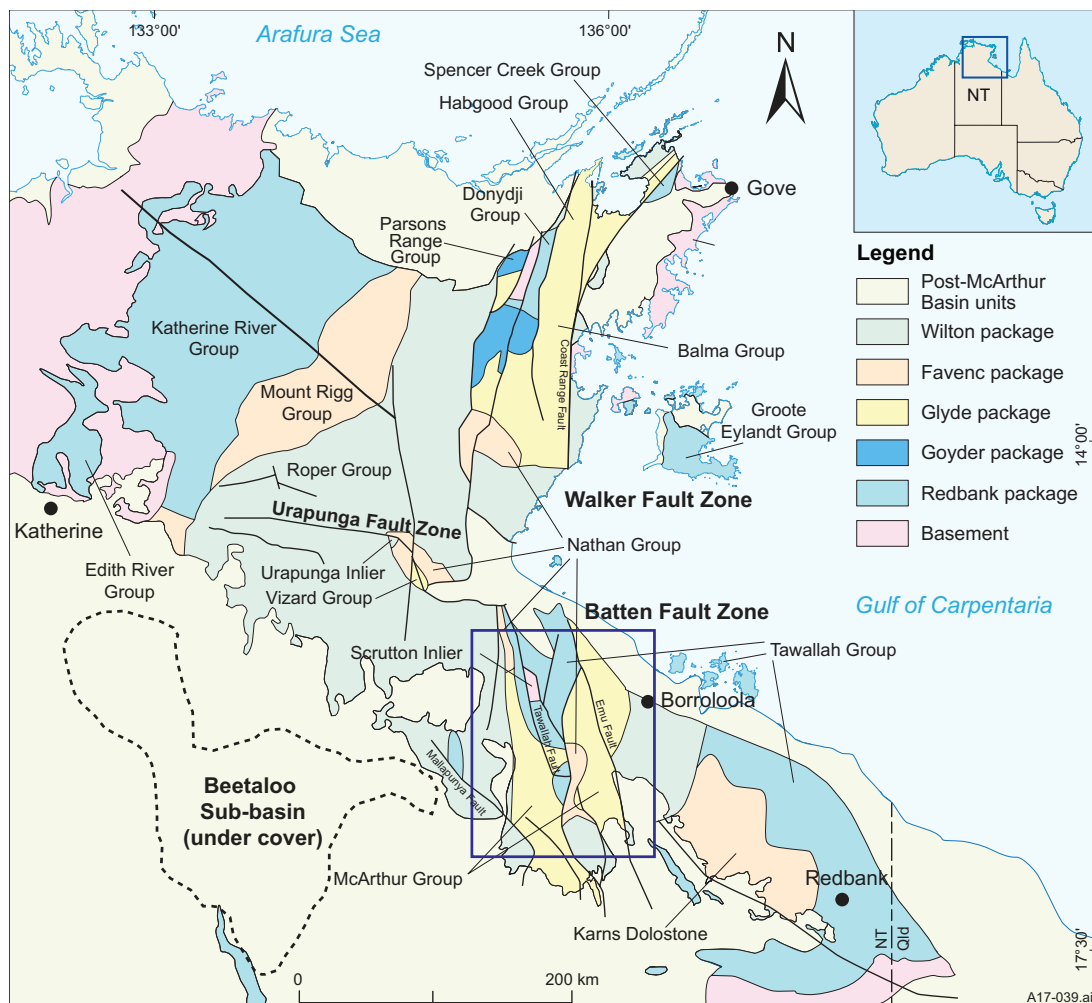


Figure 1. Regional geological map of the McArthur Basin (modified from Ahmad *et al* 2013). Inset shows the location of the interpretation shown in **Figure 2**.

likely early syn-depositional normal faults within the basin that have been reactivated during later deformation. Major northwest-trending faults, such as the Mallapunyah Fault and smaller north-south-trending strike-slip faults, appear as linear features in the magnetic data; they are often defined by differing magnetic textures on either side of the fault. A number of blind faults, trending in north-south and east-west to northwest-southeast directions, can be identified within the gravity and magnetic data. These faults are likely major basement structures that played a role in early basin formation and later sub-basin development within the McArthur Group.

Future work

Future work will involve depth to magnetic basement inversion across the Batten Fault Zone in order to constrain

the thickness of the McArthur Group. Results from this analysis, along with the geological interpretation, will be used to create geological cross-sections to be integrated into 2.75D forward models of the potential field data and a 3D geological model of the Batten Fault Zone. High-resolution 3D models useful for understanding local sub-basin development within the McArthur Group will be embedded within the regional scale model. Results will be placed into a tectonic framework to provide greater understanding of the geodynamic evolution of the greater McArthur Basin.

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We would like to acknowledge Ben Williams, Dorothy Close and Greg MacDonald for their reviews of this abstract.

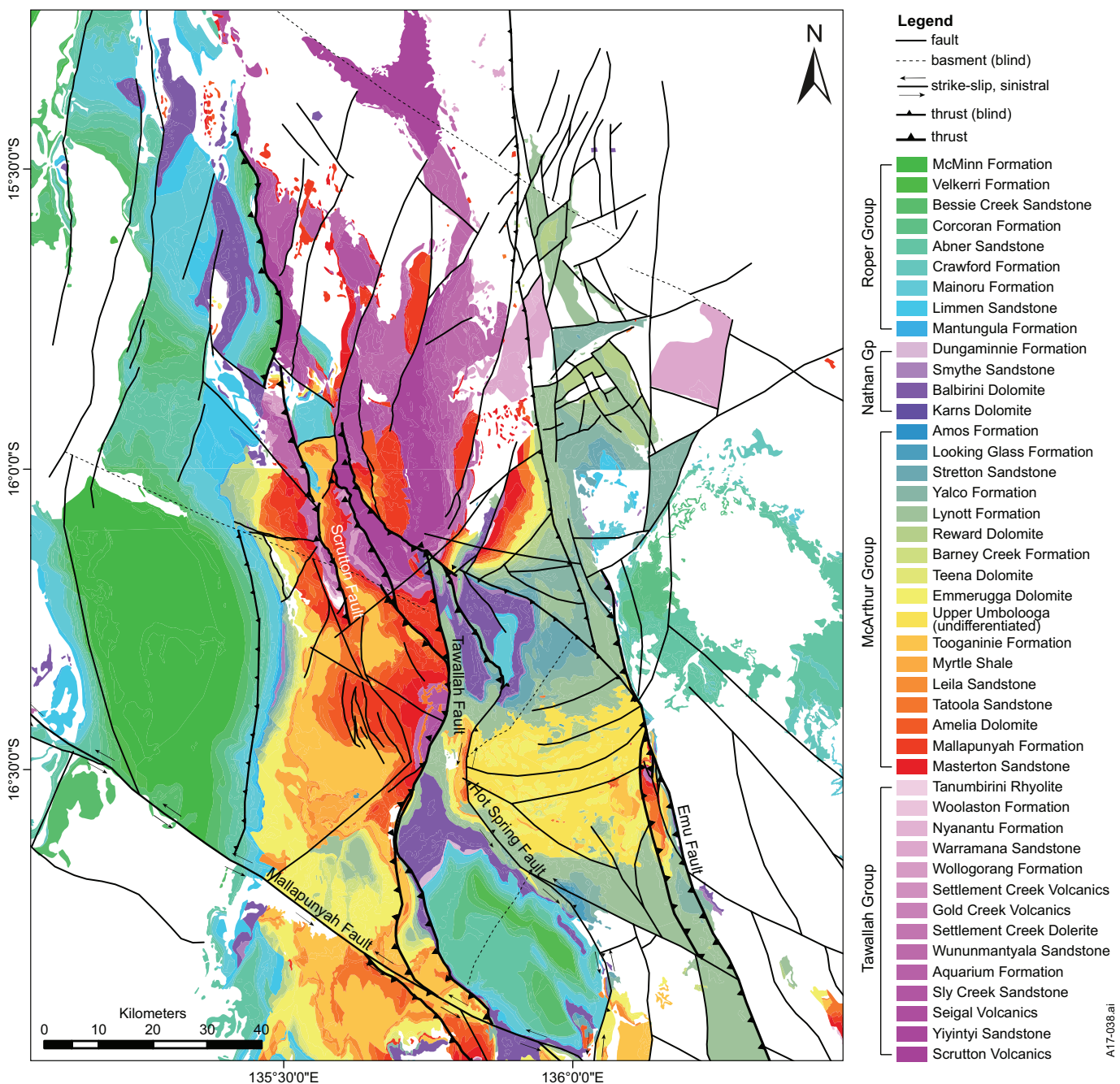


Figure 2. Geophysical interpretation of the Batten Fault Zone.

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