Overview of new geophysical resources in the Northern Territory

Tania Dhu[1,2]

A range of interpretative products focussed on the greater McArthur Basin have been completed or are currently underway. These products are compiled using either pre-competitive geophysical data acquired under the *CORE* initiative or high-resolution data submitted through industry statutory reporting. They include the following: reprocessing of industry submitted AEM data in the Batten Fault Zone, development of an interpretation-ready Kingdom® seismic project over the Beetaloo Sub-basin, and application of the same to assist in defining the Beetaloo Sub-basin boundary. Elsewhere in the greater McArthur Basin, a higher-resolution ground gravity survey has been acquired over the Batten Fault Zone through collaboration with CSIRO. In addition, three new geophysical surveys were also completed under Round 9 of the Geophysics and Drilling Collaborations (GDC) program.

Batten Fault Zone

The north-trending Batten Fault Zone, located in the Palaeo–Mesoproterozoic greater McArthur Basin (**Figure 1**) hosts the world class McArthur River Pb-Zn-Ag mine, the Teena Pb-Zn deposit and several other base metal prospects. The mineralisation at McArthur River is hosted in the HYC Pyritic Shale Member of the Barney Creek Formation (Ahmad *et al* 2013). In collaboration with CSIRO, a higher resolution ground gravity survey (infilling existing 4 km spaced ground gravity to 2 km) has been acquired. Existing industry-submitted airborne electromagnetic (AEM) surveys for the same region have been reprocessed and either transformed or inverted. These data are being interpreted to assist in understanding the structure and evolution of the Batten Fault Zone (Blaikie *et al* 2018) and of the related subsurface extent and geometry of the Barney Creek Formation (Munday *et al* 2017).

The Batten Fault Zone gravity survey (**Figure 2**) infills the existing 4 km spaced gravity data of the Barkly and Southern McArthur gravity surveys (acquired by NTGS in 2009 and 2013 respectively) to 2 km station spacing. It was funded by NTGS and managed by CSIRO; it also includes CSIRO's high resolution Caranbirini gravity survey. The new survey was designed around existing open and closed file industry ground gravity and airborne gravity gradiometry surveys; it also includes several profiles of 500 m spaced gravity stations used for potential field forward modelling and inversion. The data offers improved resolution of structural and stratigraphic features within the Batten Fault Zone.

Over 40 individual AEM survey areas (**Figure 4a**) have been assessed and reprocessed using EMFlow (Macnae *et al* 1988) and, where possible, Geoscience Australia-Layered Earth Inversion (GA_LEI, Brodie and Fisher 2008). This project has involved both the geophysical assessment and value adding to existing data (Ley-Cooper *et al* 2016) and the geological interpretation of the transformed or inverted data (Munday *et al* 2017). The reprocessed AEM data will be provided as a Digital Information Package (DIP) that includes the following data: AEM reports; specifications and EMFlow descriptor files for each survey; EM flow sections and grids; GA_LEI sections and grids; and conductivity mosaics of combined surveys at different depth intervals (**Figure 4b**). The DIP will be supported by an interpretation record. Interpretation of AEM has proved useful for mapping shallow structure within the Batten Fault Zone; in certain circumstances, it can image structures that are not clear in either the gravity or magnetic data. In some areas, the geometry of conductive elements of the Barney Creek Formation are mappable within the data.

Beetaloo Sub-basin

The Mesoproterozoic Beetaloo Sub-basin is located 300 km south-southeast of Katherine and extends over an area of about 28 000 km^2 (**Figure 1**). The fully concealed sub-basin contains thick successions of Roper Group within the McArthur Basin including the Velkerri and Kyalla formations, both of which are prospective for hydrocarbon resources. Defining the boundary of the sub-basin was highly dependent on seismic interpretation; to aid this a Kingdom® interpretation ready seismic project was developed. This project will be available as a new DIP containing over 190 lines that have been adjusted to a constant seismic datum of 200 mASL.

Figure 5 shows the Beetaloo Sub-basin as two discrete areas separated by the uplifted Daly Waters Fault Zone. The boundary represents the top of the Kyalla Formation at a depth of 400 m below current-day topographic surface. The sub-basin is bounded by faults except along the western-margin where it gradually shallows (Williams in prep). Selecting a depth-contour to constrain the boundary allows a consistent approach to be applied across the entire sub-basin; the Kyalla Formation was selected as the best-constrained within the sub-basin. The boundary is based on the interpretation of 96 seismic lines constrained by 26 wells.

Geophysics and Drilling Collaborations

The GDC program provides co-funding for drilling and geophysical projects with the aim of increasing coverage in greenfields areas of the Northern Territory. **Figure 1** outlines the geophysical projects that were awarded to Independence Group NL (Aileron Province, blue polygon), Energy Metals (Ngalia Basin, red polygon) and Bowgan Minerals (Aileron Province, green polygon) in Round 9 of the GDC program.

Independence Group NL acquired over 35 000 line km of airborne magnetic data at 200 m line spacing for their Lake Mackay project (**Figure 1**; Winzar 2016). The survey was flown over the Andrew Young Igneous Complex

[1] Northern Territory Geological Survey, GPO Box 4550, Darwin NT 0801, Australia
[2] Email: tania.dhu@nt.gov.au

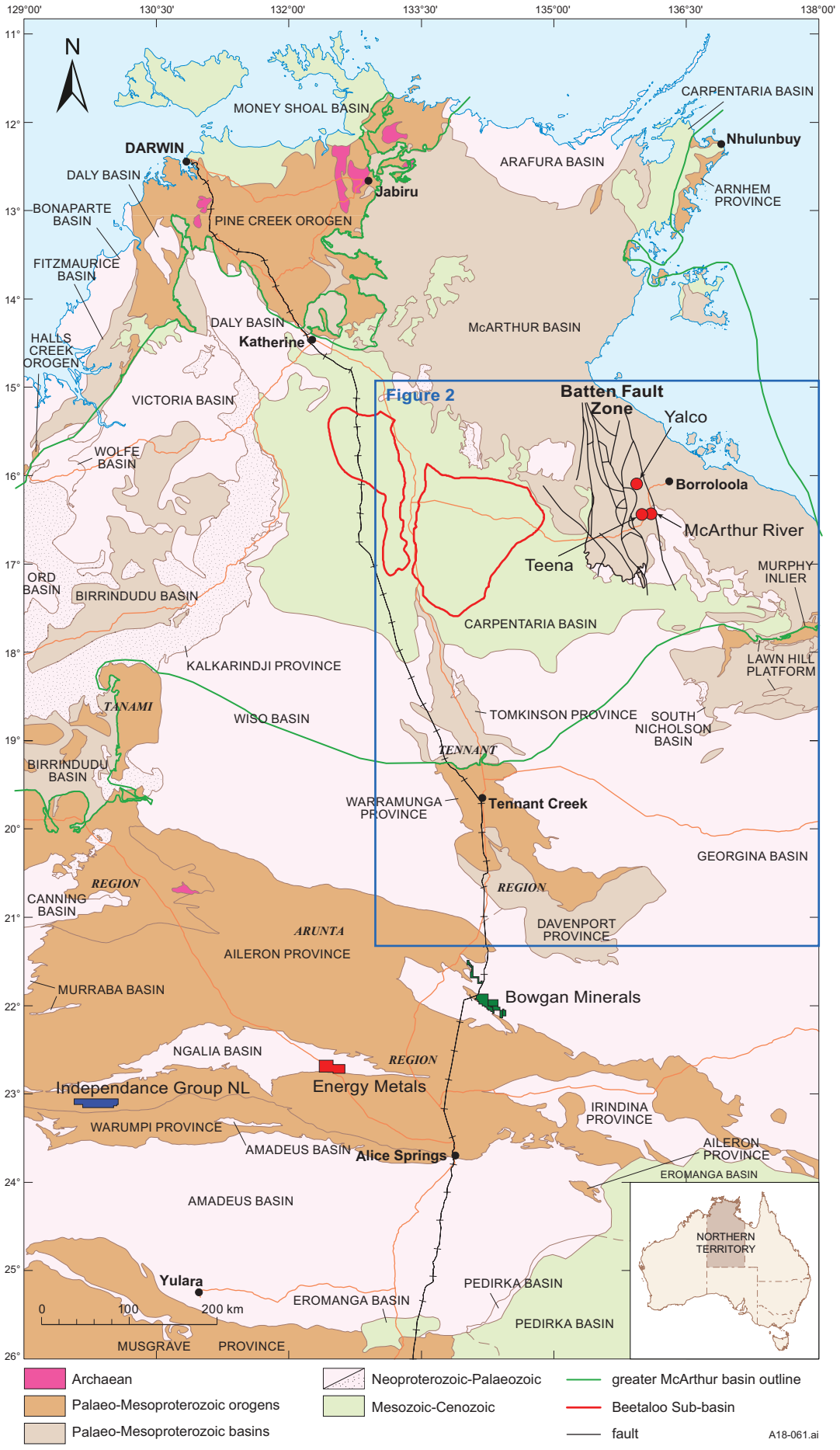

Figure 1. Map of Geological Regions of the NT showing location of greater McArthur Basin (black outline), Beetaloo Sub-basin (red outline) and GDC surveys.

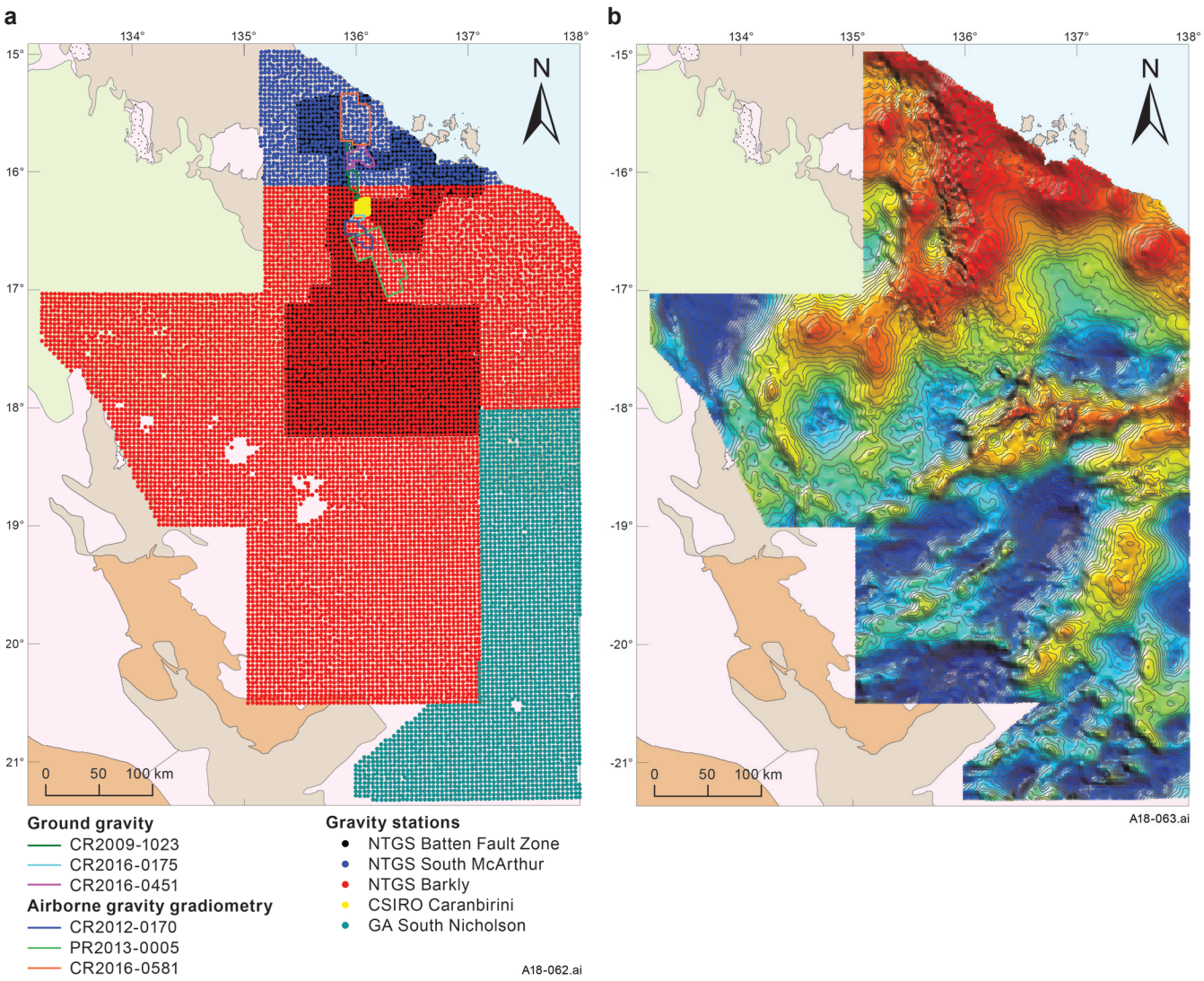

Figure 2. (**a**) Station locations for the NTGS Batten Fault Zone gravity survey (black points), infilling the pre-existing Barkly (red points) and South McArthur (blue points) gravity surveys. The South Nicholson gravity survey, acquired through by Geoscience Australia under the Exploring for the Future initiative (green points) and CSIRO's Caranbirini gravity survey (yellow points) are also shown. The Batten Fault Zone gravity survey was designed to complement existing open and closed file industry ground gravity and airborne gravity gradiometry surveys (shown in coloured polygons). (**b**) Bouguer anomaly image of the merged Batten Fault Zone, Barkly, South McArthur, South Nicholson and Caranbirini gravity surveys.

targeting IOCG mineralisation; the resultant data is being used for detailed mapping and prospect scale targeting. A passive seismic survey was completed by Energy Metals as part of a joint GDC drilling and geophysical program; the survey data was used to determine depth of Cenozoic cover (Fordyce *et al* 2016) prior to drilling. Four profiles totalling 18 line-km were completed at the Malawiri-Minerva uranium prospect in eastern Ngalia Basin. Bowgan Minerals acquired 520 ground gravity stations infilling the existing open-file 4 x 4 km spaced ground gravity data to 1 x 1 km spacing (Price 2017). The survey was completed at their Neutral Junction project, which is bordered by the Aileron Province to the south and Devonport Province to the north. Data from all these surveys are now open-file.

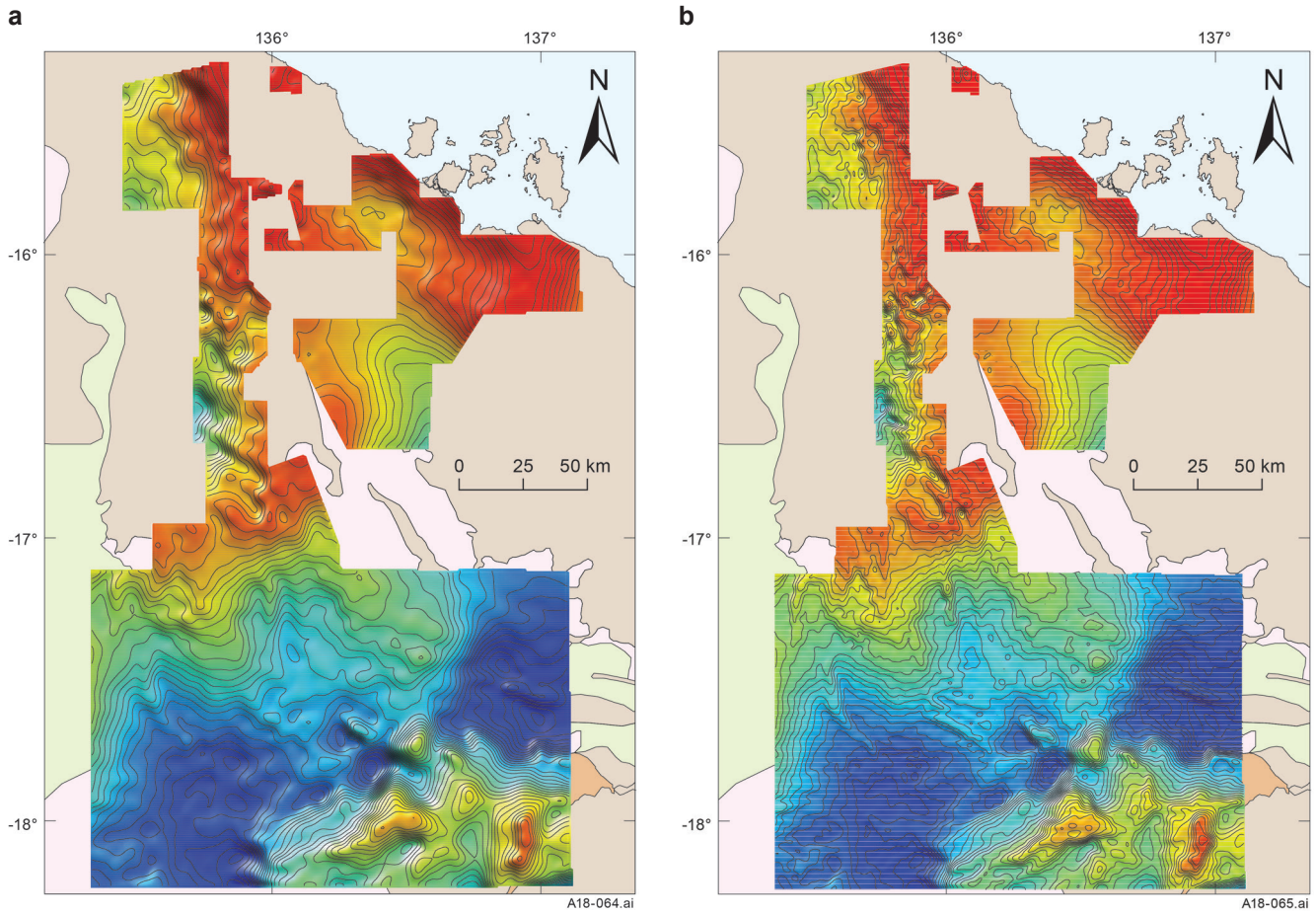

Figure 3. Bouguer anomaly image pre (**a**) and post (**b**) the NTGS Batten Fault Zone gravity survey.

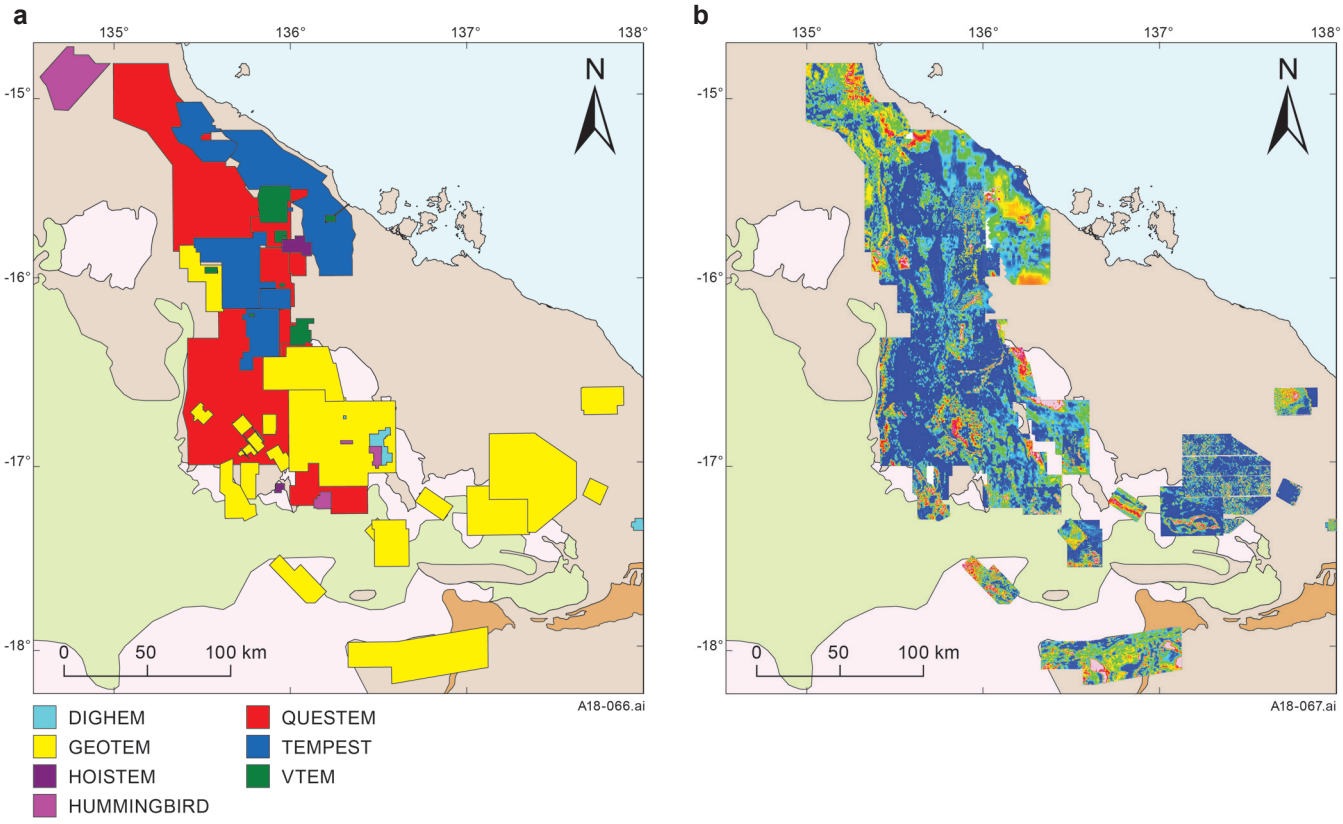

Figure 4. (**a**) Location of surveys that have been assessed for reprocessing, coloured by survey type. (**b**) Mosaic of conductivity from all processed surveys for depth interval 130–150 m.

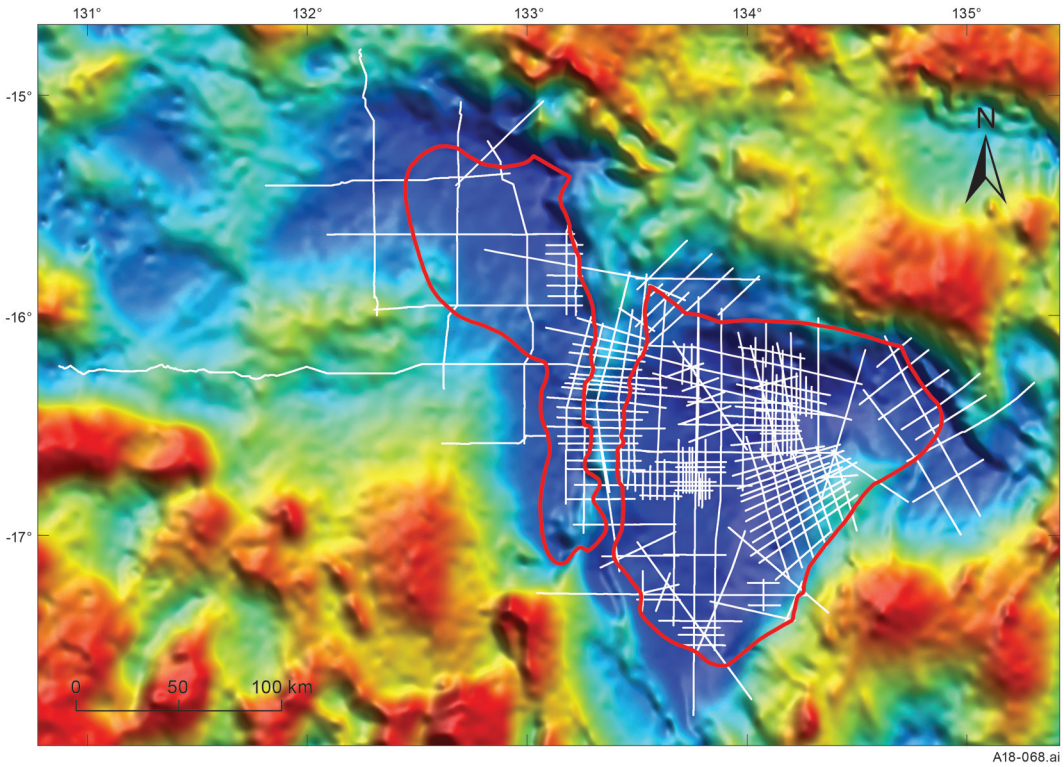

Figure 5. Location of Beetaloo Sub-basin boundary (red polygons) separated by the Daly Waters Fault Zone, overlaying the NT-wide Bouguer Anomaly gravity map. The location of seismic lines from the Kindom® seismic project are also shown (white lines).

References

Ahmad M, Dunster JN and Munson TJ, 2013. Chapter 15: McArthur Basin: in Ahmad M and Munson TJ (compilers). *'Geology and mineral resources of the Northern Territory' Northern Territory Geological Survey*, *Special Publication* 5.

Blaikie T and Kunzmann M, 2018. Understanding the architecture of the Batten Fault Zone from the regional to the sub-basin scale. Insights from geophysical interpretation and modelling: in *'Annual Geoscience Exploration Seminar (AGES) Proceedings, Alice Springs, Northern Territory, 20–21 March 2018'*. Northern Territory Geological Survey, Darwin (this volume).

Brodie R and Fisher A, 2008. *Inversion of TEMPEST AEM survey data, Honeysuckle Creek, Victoria*. Geoscience Australia for the Bureau of Rural Sciences, Canberra.

Fordyce I, Taylor W, Kerr S, Jordan D and Taylor A, 2016. 2016-2017 CORE Geophysics and Drilling Collaborations Initiative, Final Report of 2016 Program, Undercover structure of the uranium-prospective Mt Eclipse Sandstone in the eastern Ngalia Basin. Energy Metals. *Northern Territory Geological Survey, Open File Company Report* CR2016-0723.

Ley-Cooper AY, Munday T, Ibrahimi T and Cahill K, 2016. Analysis and reinterpretation of historical AEM data sets: McArthur Basin, NT: in *'Annual Geoscience Exploration Seminar (AGES) Proceedings, Alice Springs, Northern Territory, 15–16 March, 2016'*. Northern Territory Geological Survey, Darwin.

Macnae JC, King A, Stolz N, Osmakoff A and Blaha A, 1998. Fast AEM data processing and inversion. *Exploration Geophysics* 29, 163–169.

Munday T, Cahill K, Ley-Cooper AY, Soerensen C, Dhu T and Ibrahimi T, 2017. Geological constraints on the interpretation of AEM in the McArthur Basin, Northern Territory: in *'Annual Geoscience Exploration Seminar (AGES) Proceedings, Alice Springs, Northern Territory, 28–29 March, 2017'*. Northern Territory Geological Survey, Darwin.

Price G, 2017. Summary report for the program of gravity surveying conducted by Atlas Geophysical Pty Limited at the Neutral Junction Project Core Initiative, Round 9, 13 December 2016 to 11 April 2017. Bowgan Minerals. *Northern Territory Geological Survey, Open File Company Report* CR2017-0183.

Williams B, in prep. Interpretation and definition of the Beetaloo Sub-basin. *Northern Territory Geological Survey, Record*.

Winzar DJ, 2016. IGO Core Geophysics Collaboration Final Report. Independence Group. *Northern Territory Geological Survey, Open File Company Report* CR2016-0615.