# Regional geoscience and resource potential programs under the *CORE* initiative

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## Introduction

Under the 2014–2018 *Creating Opportunities for Resource Exploration* (*CORE*) initiative, the Northern Territory Geological Survey (NTGS) has undertaken a range of precompetitive geoscience projects designed to deliver new key datasets and interpretations in order to provide an integrated understanding of geological framework and resource potential of the Northern Territory.

## Regional geoscience and resource potential projects

Four areas have been targeted under the *CORE* initiative: Palaeoproterozoic Arnhem Province, Palaeo- to Mesoproterozoic Aileron Province, Palaeo- to Mesoproterozoic greater McArthur Basin and Neoproterozoic to Palaeozoic Amadeus Basin (Close 2014a, Close 2015). Projects and approaches were tailored for each target area to address gaps in regional scale datasets, increase knowledge of geological framework (ie stratigraphic correlations, structural architecture, and regional scale igneous and metamorphic events) and access the potential for regional scale base metals mineral and/or petroleum systems (**Figure 1**).

## Arnhem Province

Regional geoscience projects in the Arnhem Province under the *CORE* initiative are designed to improve the understanding of the geological framework of this basement terrane through documenting the depositional, igneous, metamorphic and deformational processes. The results of this work will be published in a series of first edition 1:100 000 geological maps (Kraus *et al* 2015).

A systemic approach to isotopic geochemistry and geochronology was integrated with the field mapping and interpreted evolution of rock units to assist in the correlation with other exposed Proterozoic basement terranes in northern section of the North Australia Craton such as the Pine Creek Orogen (Whelan *et al* 2017). Ultimately this approach will contribute to a seamless understanding of the tectonic evolution of North Australian Craton and provide insights on the underlying crustal architecture and the influences on the formation of overlying basins.

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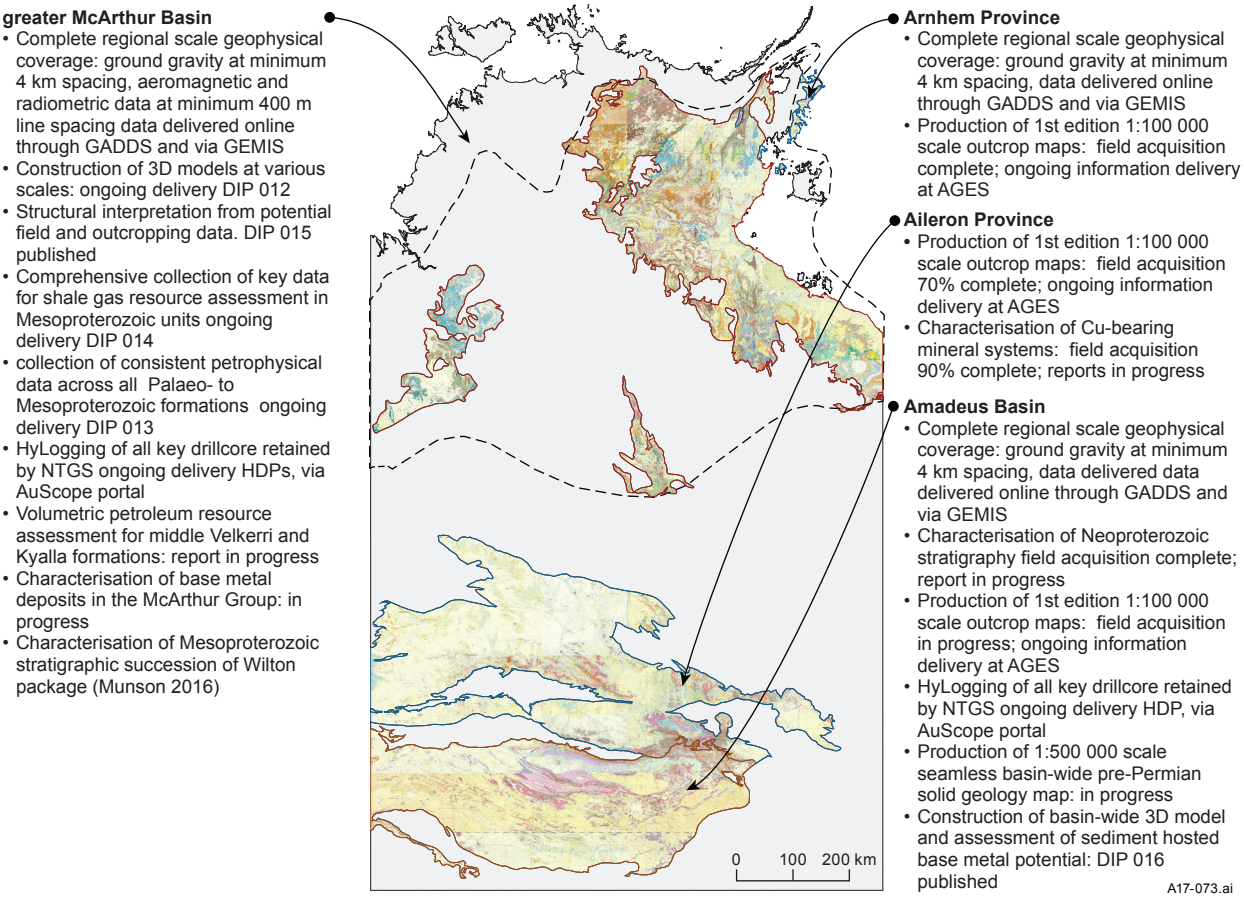


**Figure 1**. NTGS regional geoscience projects, collaborations and products under the *CORE* initiative addressing data or knowledge gaps across four targeted areas: Arnhem Province, greater McArthur Basin (linking outcropping McArthur Basin, Birrindudu Basin and Tomkinson Province), Aileron Province and Amadeus Basin.

**greater McArthur Basin**

The construction of a 3D model of the greater McArthur Basin (as defined in Close 2014b) was the identified approach to improve knowledge of the regional scale architecture for this target area. The purpose of the 3D model is to redefine the current thinking on the scale of the prospective Mesoproterozoic and Palaeoproterozoic successions, and also to better understand the evolving fault architecture that controlled the formation of the stacked basin successions. A range of 3D models, constructed at appropriate scales, provides the framework needed to understand regional scale stratigraphic correlations and unconformities, and the depth, thickness and volume of prospective stratigraphy and fault architecture influencing sediment deposition and mineralised fluid flow.

To assist in the correlation of outcropping age equivalent sedimentary successions, a project was undertaken to characterise each formation unit at type sections in each of four geological areas within the greater McArthur Basin: northern and southern McArthur Basin, Birrindudu Basin and Tomkinson Province. Characterisation involved visiting type and reference sections as described in the Australian Stratigraphic Units Database (Geoscience Australia 2017) for each of the formations in these geological areas. A standard suite of field observations were made to assist in understanding depositional environment and palaeogeographic history; representative samples were collected for petrographic description, multi element geochemistry and maximum deposition age through U–Pb dating of detrital zircons. The characterisation of the Mesoproterozoic successions across the northern and southern McArthur Basin, Birrindudu Basin and Tomkinson Province is now complete and published (Munson 2016). A complementary process for the Palaeoproterozoic successions is in progress.

Prior to 2014, regional scale geophysical coverage across the greater McArthur Basin comprised ground gravity coverage largely at 11 km spacing, with variable magnetic and radiometric data coverage creating an obvious data gap to be addressed. Under the *CORE* initiative, the entire greater McArthur Basin is now covered with publically available 4 km or better spaced gravity stations and 400 m line spaced aeromagnetic and radiometric data (Dhu 2015, 2016).

The value of the improved regional geophysical datasets is being increased through a project implemented under the *CORE* initiative to collect and collate petrophysical data. This project involves the compilation of existing rock property data submitted to NTGS through industry reporting together with the collection of a new standard suite of rock property data from the drill core lodged at the NTGS Core Facilities (Hallett 2016, Dhu and Hallett 2017). Petrophysical data collection has focussed on the greater McArthur Basin to ensure provision, where possible, of a statistically valid number of rock property datasets representative of each stratigraphic formation.

The increased resolution of the regional geophysical datasets supported by petrophysical data provides a key input data set to the construction and validation of the 3D models of the greater McArthur Basin. A geophysical and structural interpretation of the greater McArthur Basin (DIP 015) was undertaken based on available gravity and magnetic data prior to the completion of in-fill regional geophysical surveys and acquisition of rock property data. This interpretation provided the basis of fault network architecture for the first phase construction of the 3D model at the largest (regional) scale (Bruna and Dhu 2016). With the completion of the geophysical acquisition phase under the *CORE* initiative and through a collaborative project with CSIRO, a further structural interpretation of recently acquired potential field data is refining this fault architecture modelling. The incorporation of stratigraphically representative petrophysical data will enable 3D models to be geophysically constrained (Blaikie and Kunzmann 2017).

The Batten Fault Zone, a major north-trending structural domain within the southern McArthur Basin, is the location of significant to world class, sediment-hosted base metals deposits such as Myrtle, Teena and McArthur River. Understanding the development of Palaeoproterozoic sub-basins in this Fault Zone, the host of these large scale base metals deposits, is essential for targeting further discoveries. Through collaboration between CSIRO and NTGS under the *CORE* initiative, a series of projects have been designed to provide a multi-disciplinary approach to investigate sub-basin development and characterise sediment-hosted mineral systems.

High resolution geophysical data available through industry submissions is being used to construct a refined 3D model within the Batten Fault Zone. The intention of this model is to define the structural controls on sub-basin formation and thereby provide an architectural framework for not only basin-fill, but also for the conduits of syn- and epigenetic fluid flow.

A program of high resolution, systematic, sedimentological logging of the middle McArthur Group in drill core adjacent to major faults in the Batten Fault Zone is allowing insight into spatial facies variations and depositional environments; this provides a consistent basin-fill framework in which to investigate chemical and isotopic variations (Kunzmann *et al* 2017).

The construction of a high resolution 3D model over the Batten Fault Zone that can accommodate structural architecture, basin-fill facies and geometry, and geochemical and isotopic trends will provide the context to the deformation fluid flow modelling phase of the project. This modelling will test the key ingredients including fault orientation related to base metals deposition within the Fault Zone.

The construction of the regional 3D model (Bruna and Dhu 2016) with a regional scale stratigraphic correlation between Mesoproterozoic units across the greater McArthur Basin has provided a volume control for hydrocarbon reservoir intervals (Revie 2017); this is a critical element in determining a resource estimate for shale gas plays in the Kyalla and Velkerri formations in the Beetaloo Sub-basin. Under the *CORE* initiative, a project was undertaken to systematically collect a consistent suite of analytical data (eg total organic carbon content, programmed pyrolysis, elemental kerogen, clay mineral content etc) essential for determining areas of increased potential for hosting shale petroleum plays (Revie and Edgoose 2015). These were collected from samples obtained from open file drill core that intersected Mesoproterozoic stratigraphy across the greater McArthur Basin; this new data was also collated with open

file industry data. NTGS has provided ongoing release of these analyses and data (Revie 2016).

Weatherford Laboratories were commissioned by NTGS to undertake a volumetric petroleum resource assessment for the middle Velkerri and the Kyalla formations within the Beetaloo Sub-basin based on the key data controls acquired under the CORE initiative (Revie 2017). This resource assessment is based only on open file information and data to ensure reproducibility of results. Future incorporation of currently confidential information will continue to add to the confidence of this petroleum resource assessment.

**Aileron Province**

Under the *CORE* initiative, NTGS continues the long term commitment to provide updated geological maps using modern analytical techniques delivering seamless interpretation of the protoliths to exposed geology. Through a protolith-based approach, the understanding of the tectonic evolution of the depositional sequences, the magmatic phases, and the regional metamorphic overprints of the southern margin of the North Australian Craton continues to improve (Reno *et al* 2017).

The eastern section of the Aileron Province has been targeted under the *CORE* initiative to meet this objective and to provide a modern geological framework for formation analysis of copper-bearing mineralisation systems. The Jervois mineral field has well exposed and explored polymetallic deposits that offer an excellent opportunity to characterise this mineral system and provide a template for contrasting other Cu-based mineral systems throughout the Aileron Province (McGloin 2017).

**Amadeus Basin**

The Neoproterozoic stratigraphy of the Amadeus Basin is currently a target for petroleum exploration (Debacker *et al* 2016). It also contains many elements necessary for sediment-hosted base metals mineral systems. However, much of the published regional scale geology across the Amadeus Basin is based on investigations by BMR/AGSO from the 1960s to 1980s. Under the *CORE* initiative, a project was undertaken to characterise and redefine Neoproterozoic stratigraphic units using modern techniques to provide a basis for basin-wide correlations (Normington *et al* 2015). This revised understanding of the Neoproterozoic stratigraphy is now being applied to field mapping and updating 1st edition mapsheets published in the 1960s (Henbury 1:250 000 and Henbury 1:100 000 geology) with the distribution of the newly defined units.

The construction of a pre-Permian basin-wide solid geology map at 1:500 000 scale that also incorporates the distribution of the newly defined units is underway. This map will assist in determining areas of insufficient or incomplete knowledge on stratigraphic correlation or structural overprint and thereby help to prioritise future field mapping projects. The 1:500 000 scale basin-wide distribution of stratigraphy will also provide the basis for future 3D model of the Amadeus Basin to be integrated with newly acquired regional scale seismic data from industry.

**Geophysics and Drilling Collaborations program**

New precompetitive geoscientific data is also available through the Geophysics and Drilling Collaborations program funded annually under the current *CORE* and previous initiatives. The objective of the program is to co-invest with industry in the acquisition of new data in areas of limited information. Exploration projects that seek to undertake either regional scale geophysics, diamond drilling in greenfields areas or use innovative geophysical techniques on prospect scales are eligible to receive co-funding of 50% of direct acquisition costs up to a maximum of $100 000. Data and information derived from co-invested projects is open filed six months after field collection.

The program is intended to provide an incentive to industry to undertake 'high risk' acquisition whilst providing availability of the resultant information to all, thereby increasing geoscientific and resource potential knowledge in areas of limited data. The program is funded at $750 000 per year under each year of the 2014–2018 *CORE* initiative.

Round 9 of the program attracted a diverse range of projects across many geological regions within the Territory. These include:

- acquisition of over 30 000 line km of magnetic and radiometric data at 200 m spacing over the western Aileron Province and nearly 500 gravity stations at 1 km spacing in the eastern Aileron Province
- acquisition of 18 line km of passive seismic and three 200 m diamond drillholes testing depth of cover in the Ngalia Basin
- approximately 900 m diamond drilling testing SEDEX and VMS style mineralisation in the Pine Creek Orogen
- over 800 m diamond drilling in West Arnhem Land testing depth to Mesoproterozoic unconformity, Palaeoproterozoic stratigraphy and geochemical vectors
- approximately 500 m of diamond drilling testing unexposed Palaeoproterozoic stratigraphy in the Tanami Region
- nearly 2 km of diamond drilling investigating stratigraphic equivalents to the highly prospective McArthur Group in the northern McArthur Basin
- approximately 800 m diamond drilling testing stratigraphic equivalents to the McArthur Group in the underexplored Lawn Hill Platform.

The location of these co-funded projects and the associated open file company report numbers can be found on the Geophysics and Drilling Collaborations webpage: www.minerals.nt.gov.au/collaborations.

Spatial indexes for regional scale geophysical acquisition and drillhole locations from projects co-funded under the Geophysics and Drilling Collaborations program will be updated in the Spatial Territory Resource Information Kit for Exploration (STRIKE).

The final round of the Geophysics and Drilling Collaborations program to be funded under the *CORE* initiative is now open for applications. Closing date is 26 April 2017 with applications to be submitted by 10am CST. Successful applicants will be announced in May 2017.

For further information please visit www.minerals.nt.gov.au/collaborations.

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