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

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1. CSIRO; 2. Northern Territory Geological Survey

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Project overview

- 3 year collaborative agreement between CSIRO and NTGS. Aims to:

- **Improve understanding of the 3D structural architecture of parts of the greater McArthur Basin through the analysis and interpretation of geophysical and geological data**

  - Achieved geological interpretations of geophysical data including:
    – Gravity
    – Magnetics
    – Radiometrics
    – Airborne EM
    – Seismic data

  - Modelling of potential field data:
    – 2D forward modelling (cross-sections)
    – 3D inversion
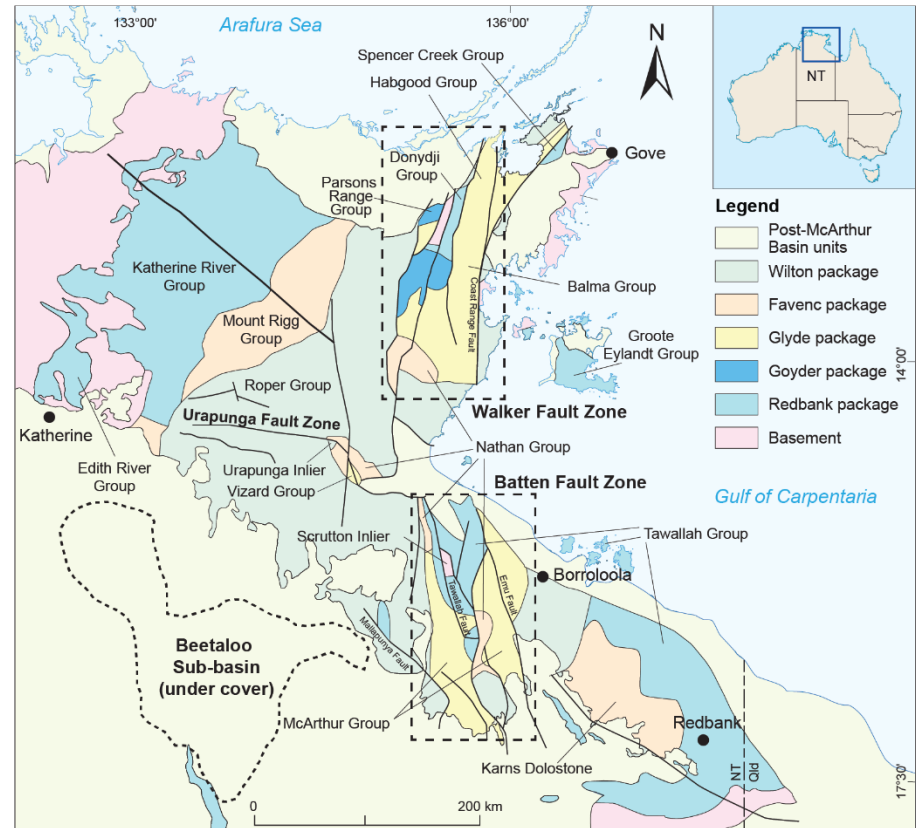
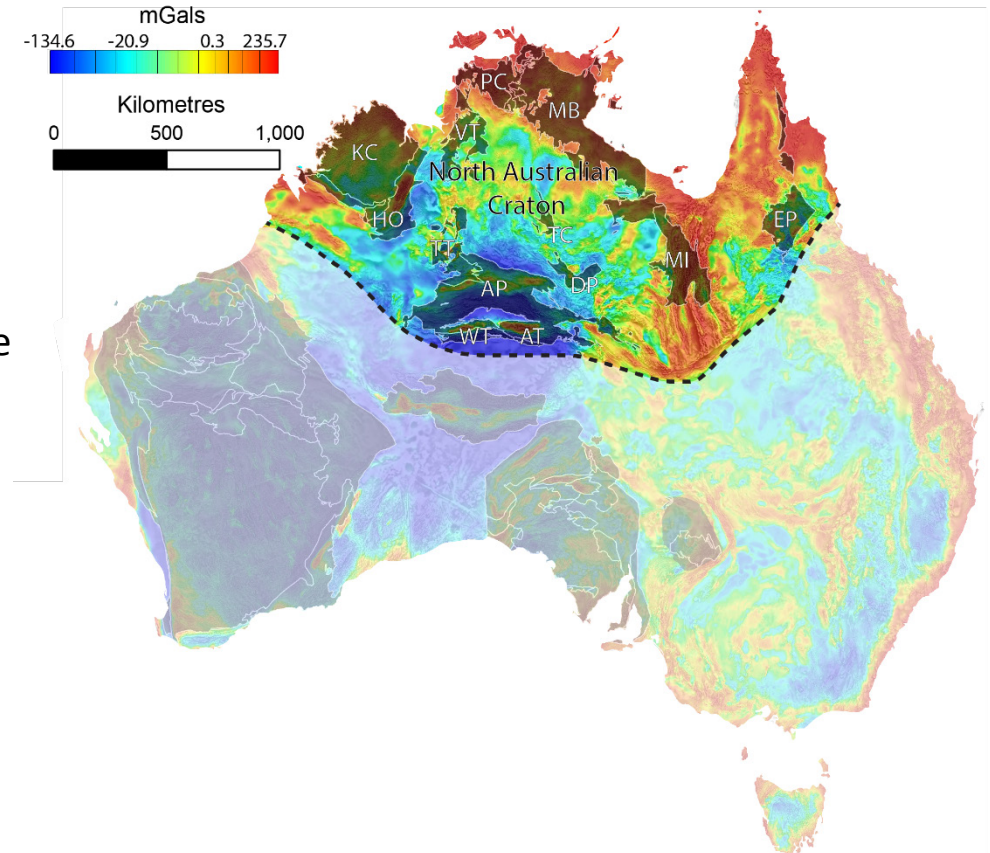Modified after Ahmad et al. 2013

Key research areas

- Interpretations will be focussed on the follow key areas:

  - **Beetaloo sub-basin**

  - **Batten Fault Zone**

  - **Walker Fault Zone**

- Constrain the 3D distribution and structural controls of the stacked depositional packages
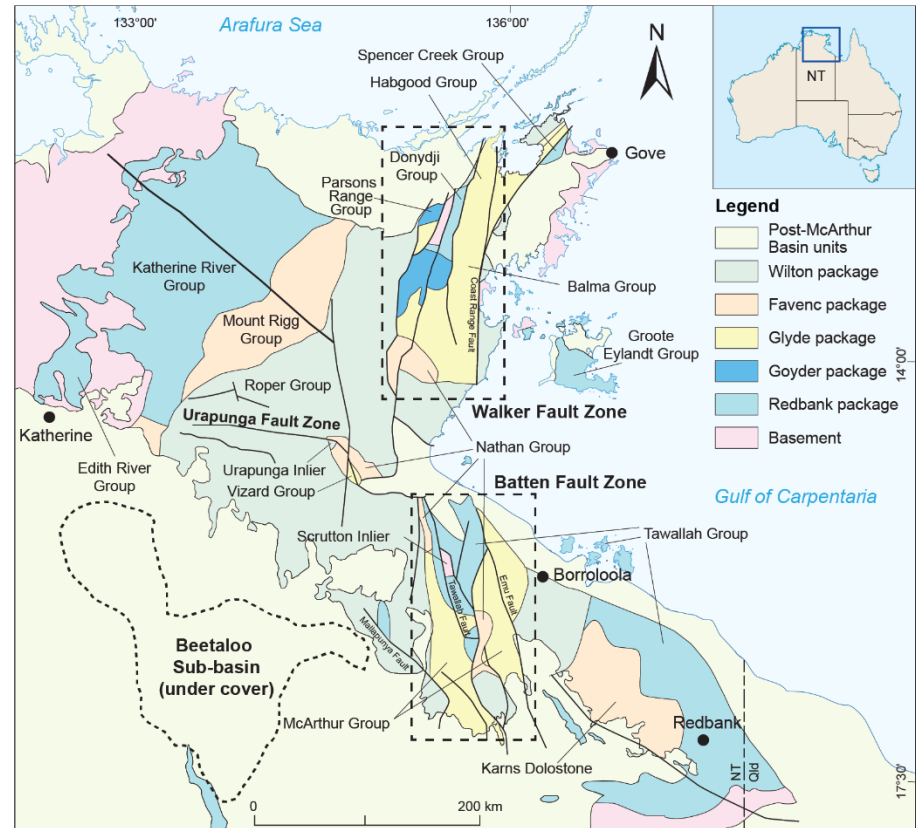
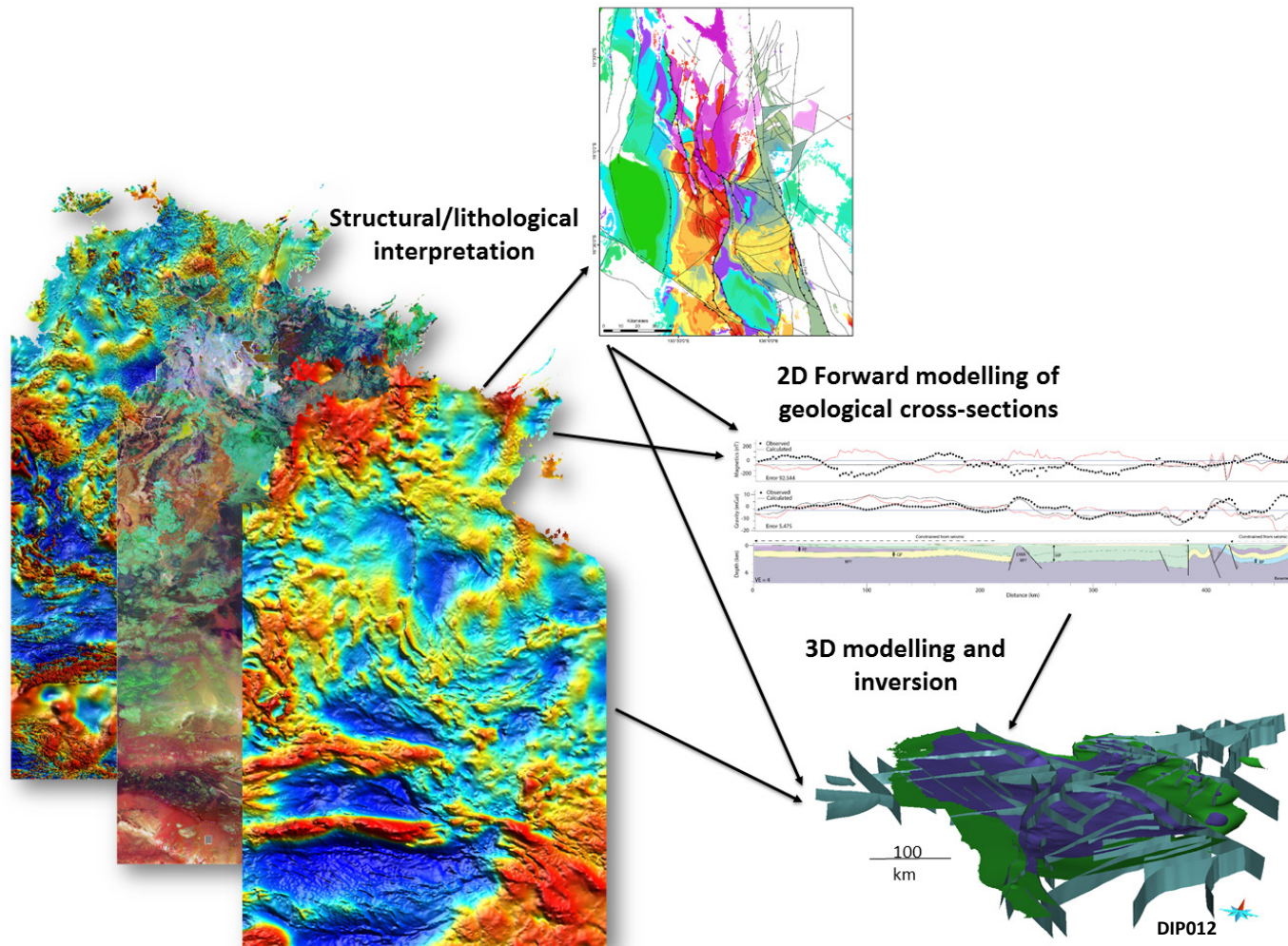Modified after Ahmad et al. 2013

Key research areas

- Updating the regional scale interpretation of the greater McArthur Basin produced by PGN:

  - Interpret major basin structures

  - Determine timing and kinematics of faults, and how each depositional package evolved within the tectonic framework of the North Australian Craton

- Update the synthesis of the tectonic history and development of the basin through time based on new results


Blaikie et al. (2017)

Interpretation Workflow

Structural/lithological interpretation

2D Forward modelling of geological cross-sections

3D modelling and inversion
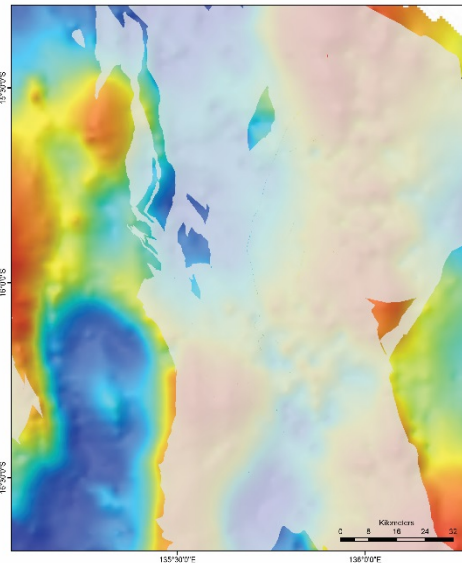
100 km

DIP012

Batten Fault Zone

- Understand the 3D structural architecture of the BFZ, with a focus on improving understanding of sub-basin development within the McArthur Group

- Available data
  - Gravity
    - 4 km regional data
    - Open file high-resolution surveys
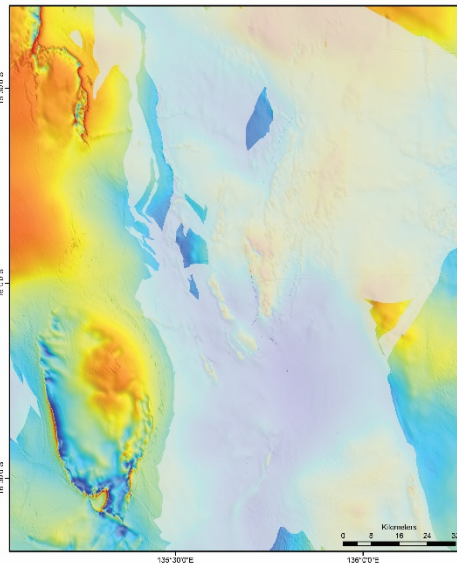 - Magnetics
  - Radiometrics
  - Seismic
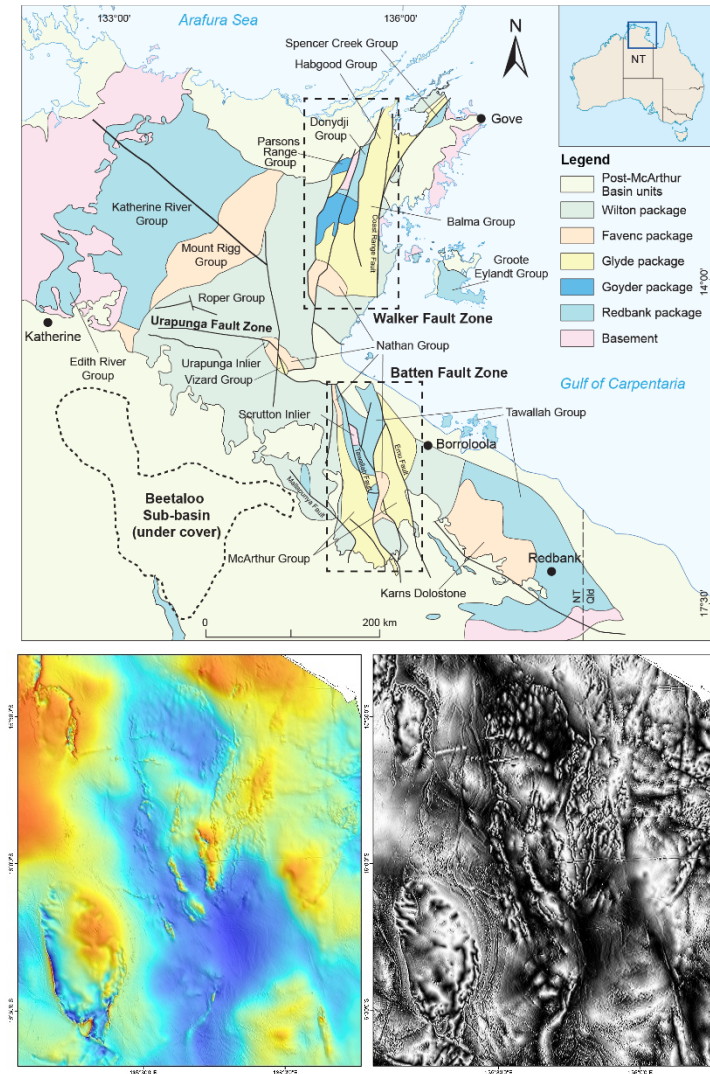
BFZ Geophysics – Roper Group (Wilton Package)

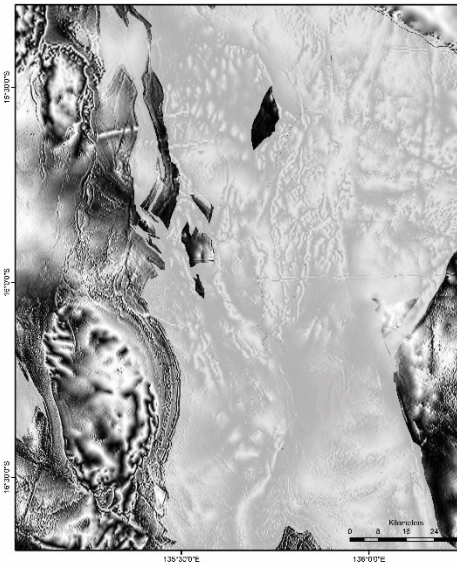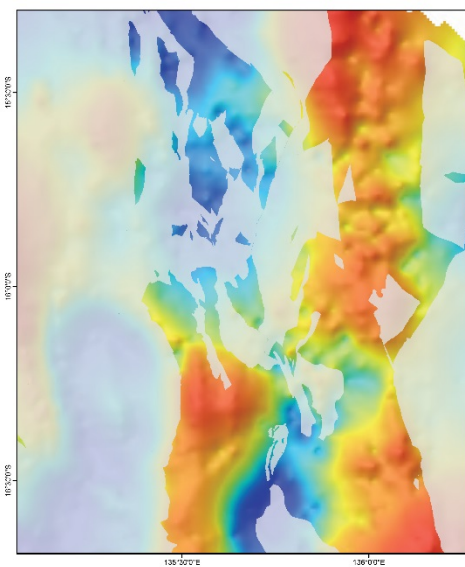| Package	Group	Gravity	Magnetic	Radiometric
Wilton	**Roper**	**Gravity low**	**Magnetic low, mag high from dolerite intrusions**	**Mantungula to Crawford Formations have high K content Formations above the Abner Sandstone have a Th-rich response. Some shales have an U-enriched signal**
Glyde	McArthur	Gravity high	Smooth, long-wavelength response. Varies from magnetic high to low	High K content
Redbank	Tawallah	Predominantly gravity low	Magnetic high, but can be variable across the SE of MB	Volcanics have a higher K content, Sandstone formations are more Th-enriched

Gravity

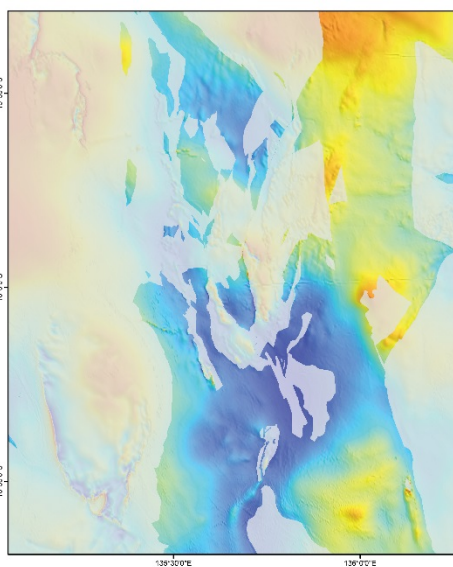Magnetics RTP

Magnetics TDR

Radiometrics

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BFZ Geophysics – McArthur Group (Glyde Package)

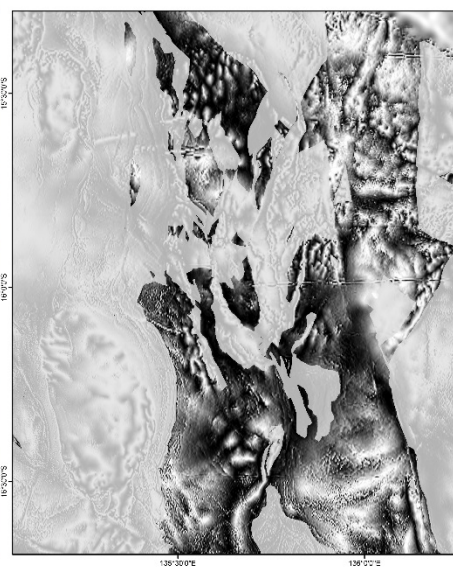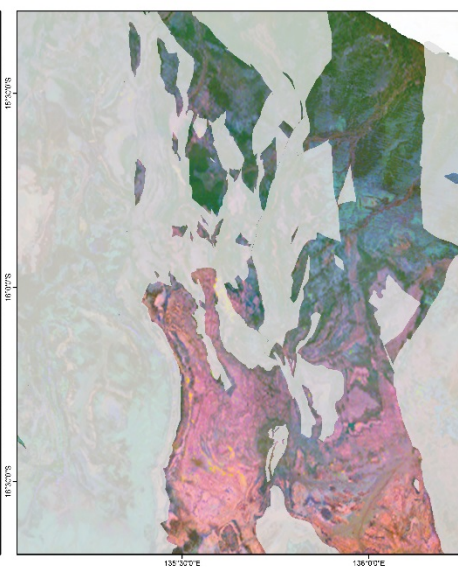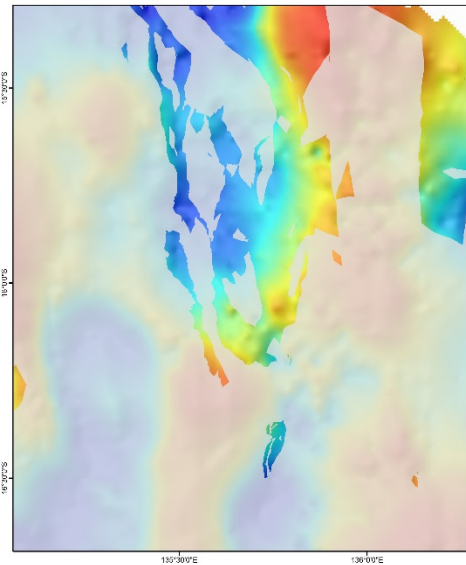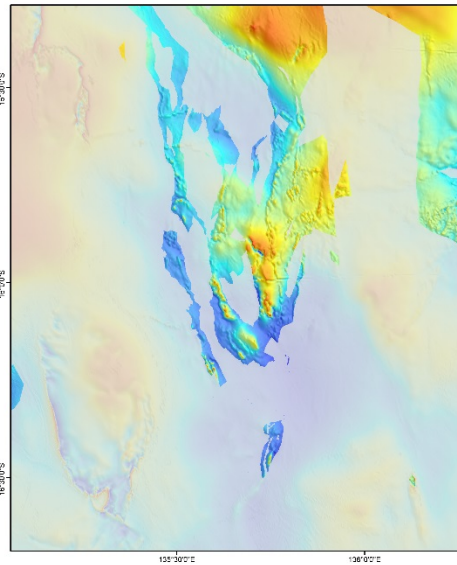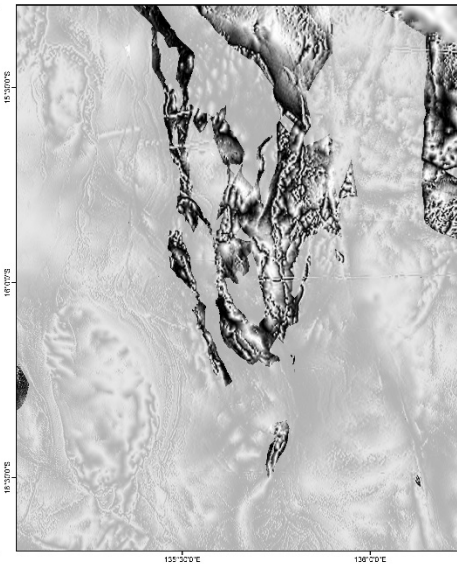| Package	Group	Gravity	Magnetic	Radiometric
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Redbank	Tawallah	Predominantly gravity low	Magnetic high, but can be variable across the SE of MB	Volcanics have a higher K content, Sandstone formations are more Th-enriched

Gravity

Magnetics RTP

Magnetics TDR

Radiometrics

BFZ Geophysics – Tawallah Group (Redbank Package)

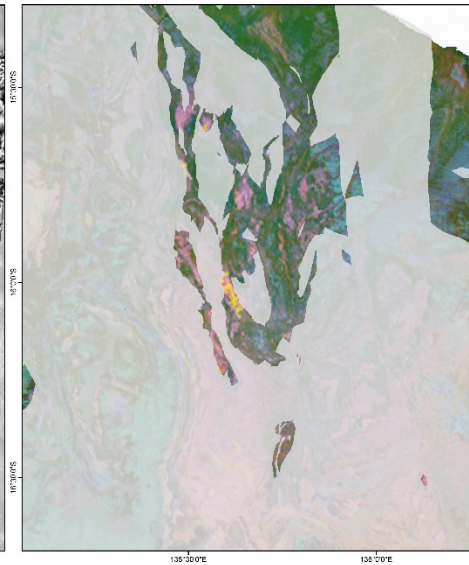| Package	Group	Gravity	Magnetic	Radiometric
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Redbank	**Tawallah**	**Predominantly gravity low**	**Magnetic high, but can be variable across the SE of MB**	**Volcanics have a higher K content, Sandstone formations are more Th-enriched**

Gravity

Magnetics RTP

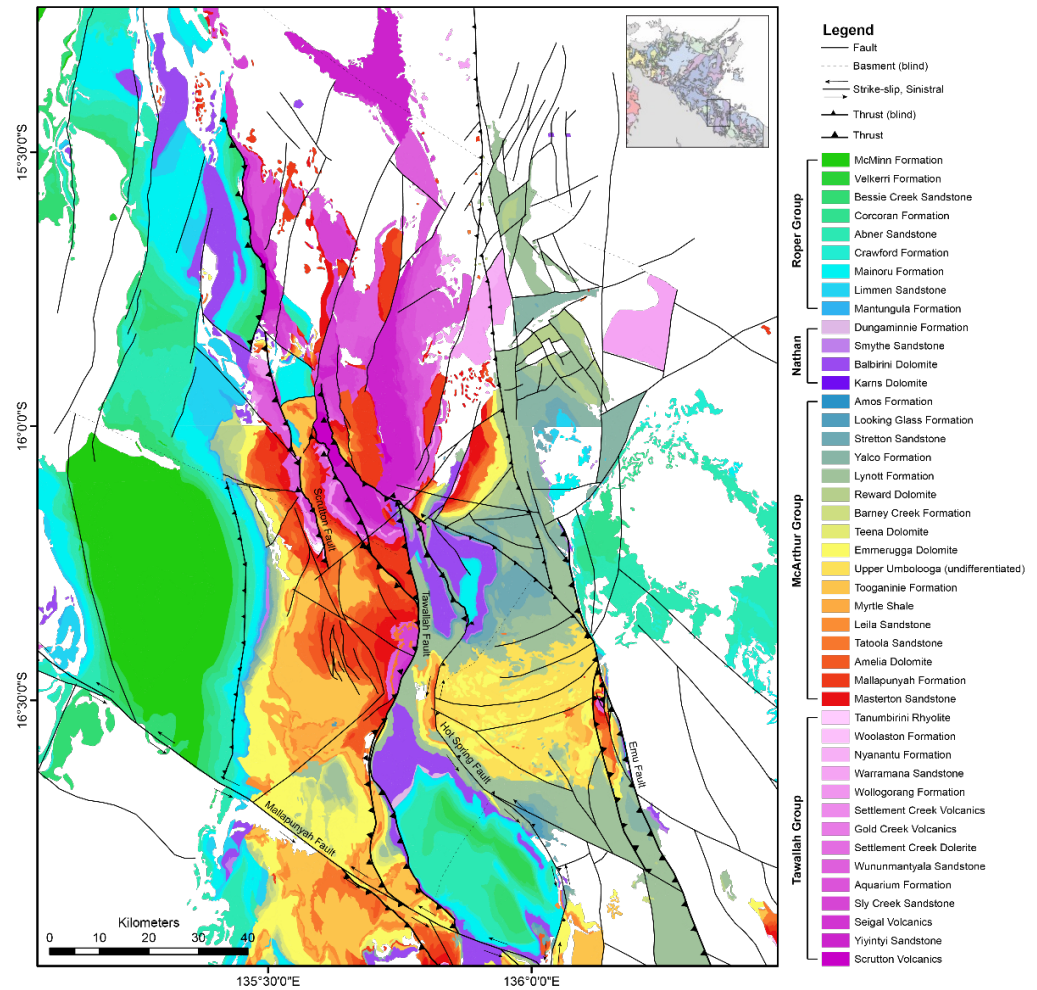## Magnetics TDR

Radiometrics

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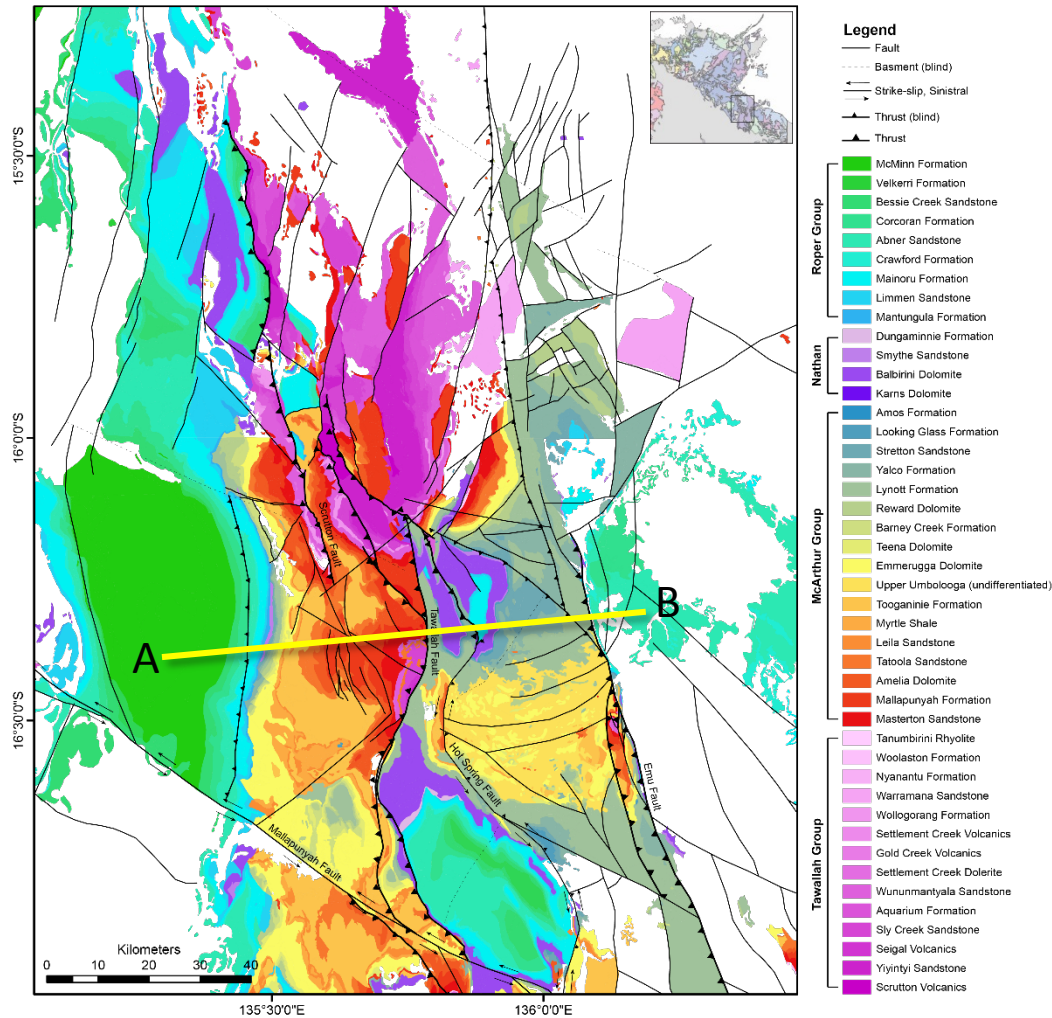# Batten Fault Zone – Regional interpretation
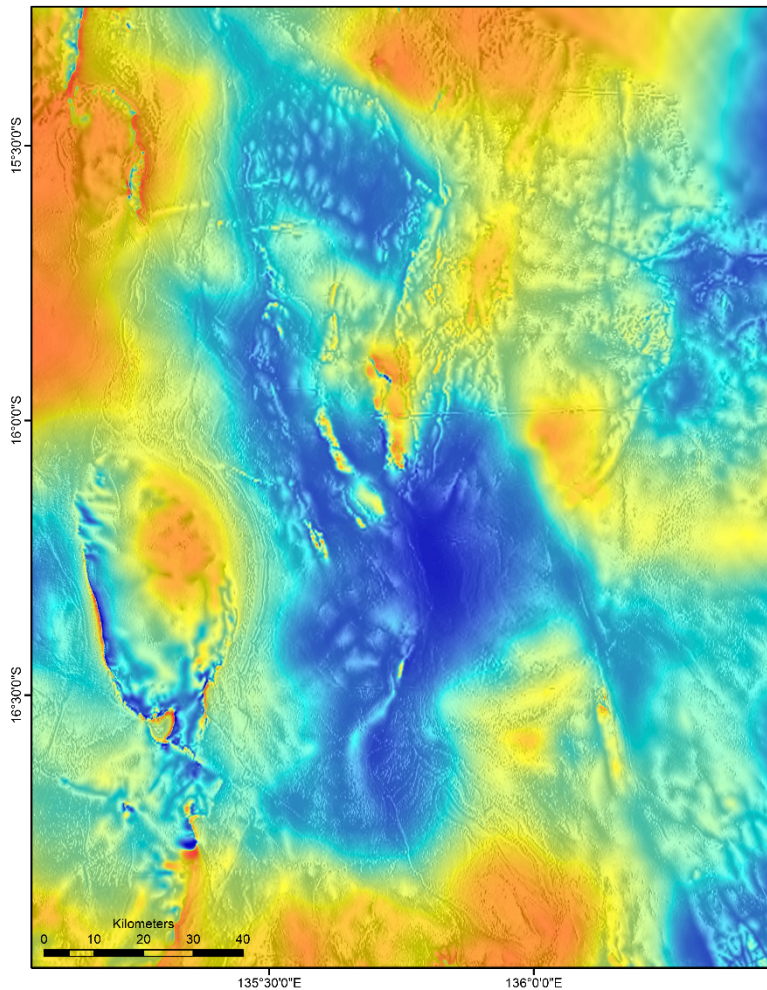
A) Reduced to pole magnetics on tilt derivative

**B)** Structural/stratigraphic interpretation of the Batten Fault Zone

Batten Fault Zone - Future Work

- 2D forward models
  - Multiple sections will be used to constrain a 3D geological model for the BFZ
    - Regional scale model – defining the overall architecture of the BFZ
    - Modelled at scale of depositional packages. Some assumptions have to be made for this
 - Complemented by local high-resolution models
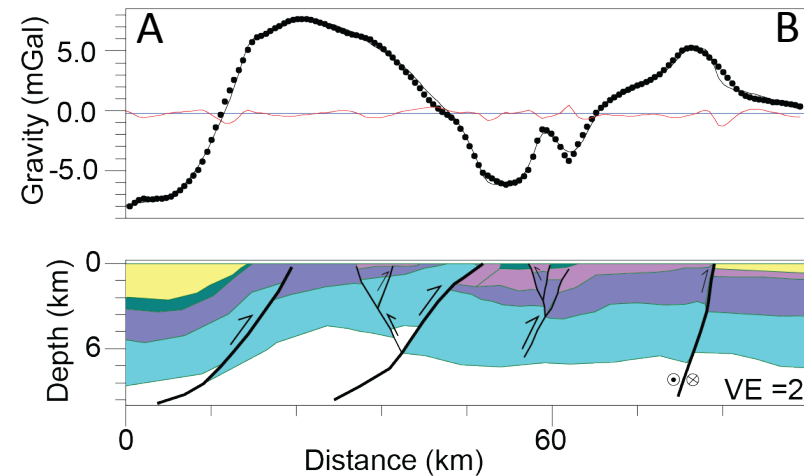
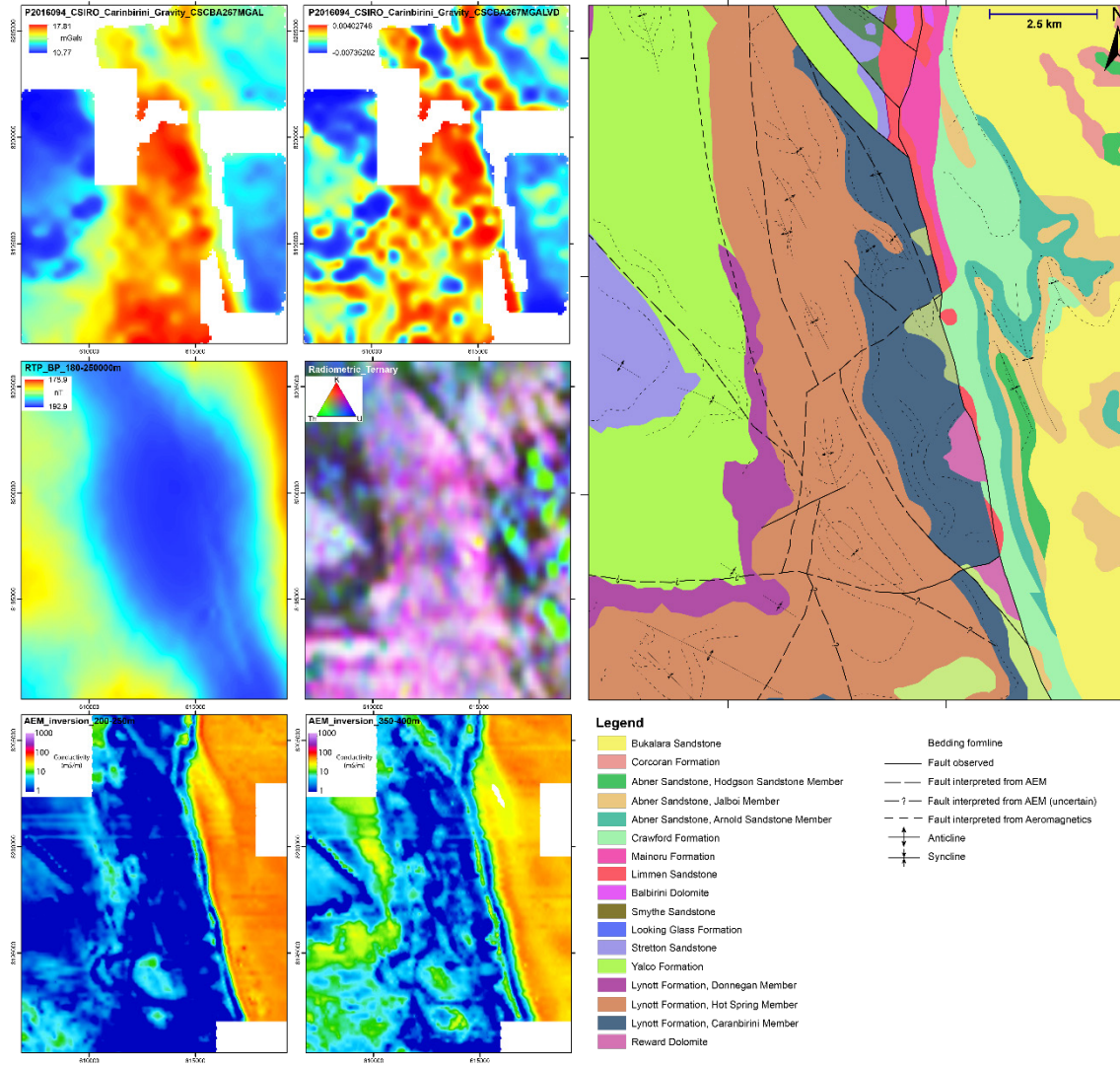# Batten Fault Zone – local case studies
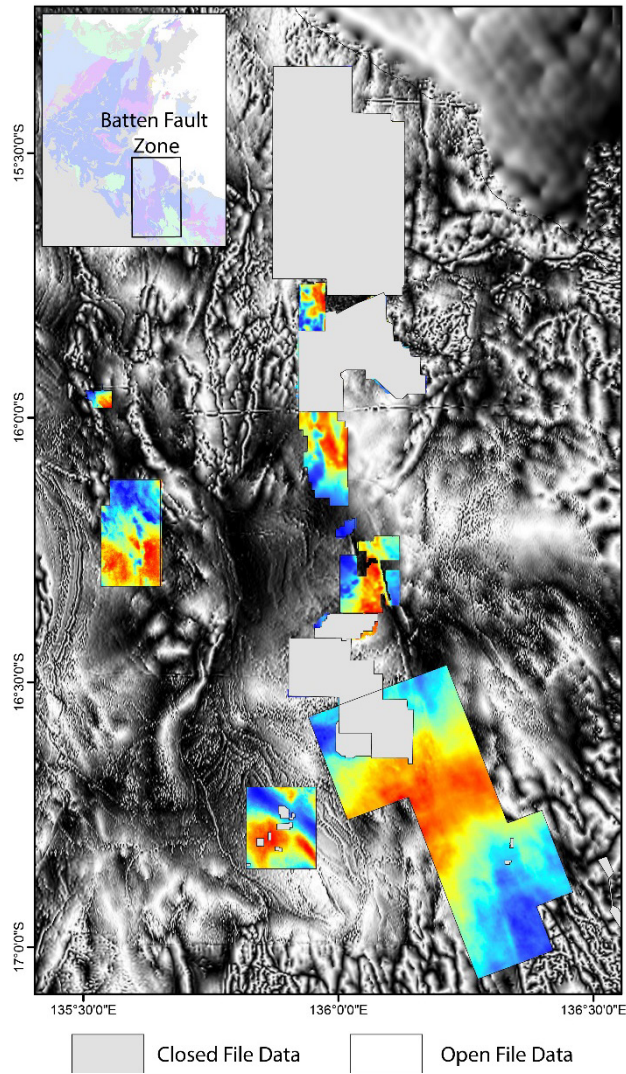
- Relatively good coverage of high resolution gravity data along the Emu Fault

- High-resolution localised case studies
  - e.g., Caranbirini, Glyde River sub-basin
  - Focus on interpretation/modelling down to formation scale
  - Model sub-basins within McArthur Group
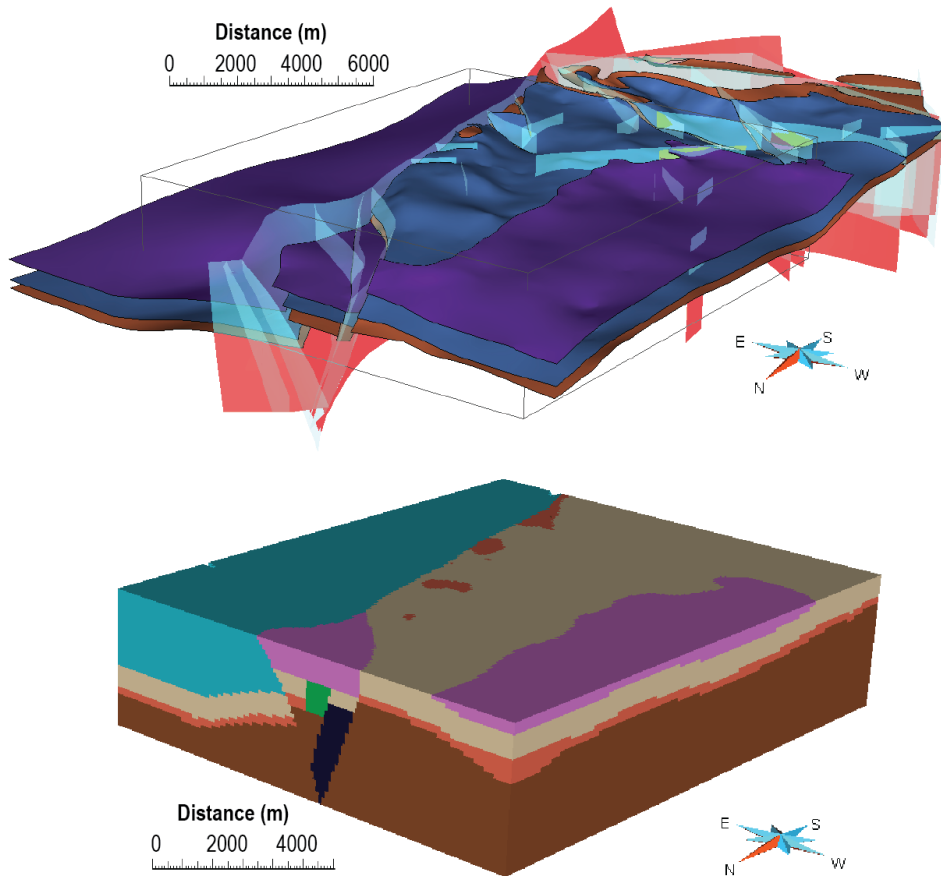
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Case-study - Caranbirini
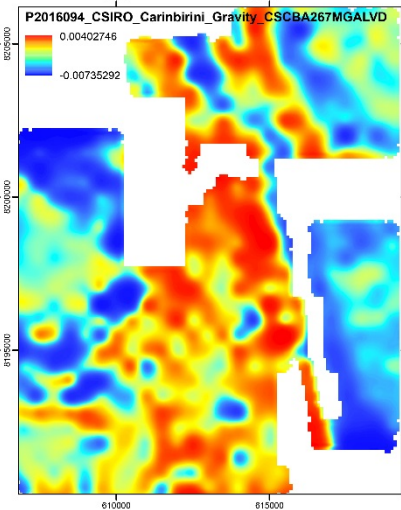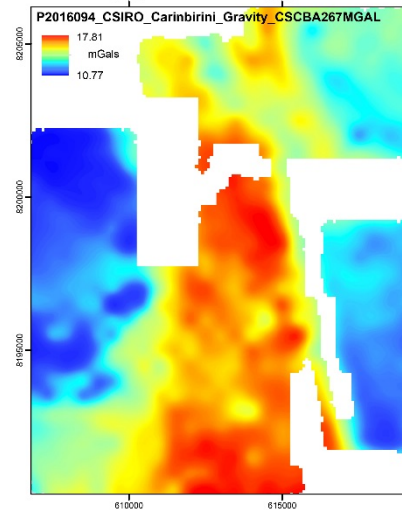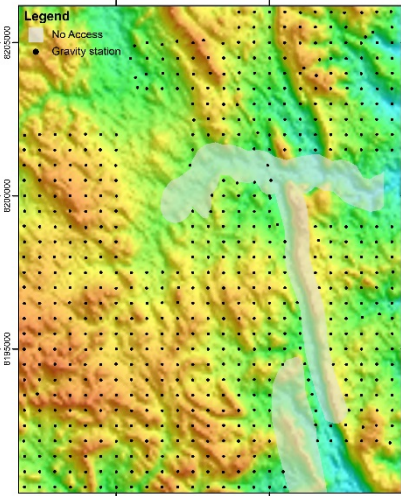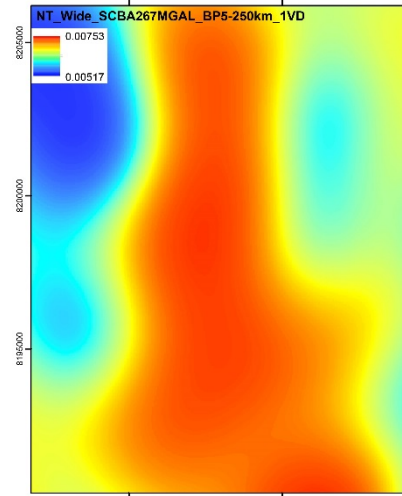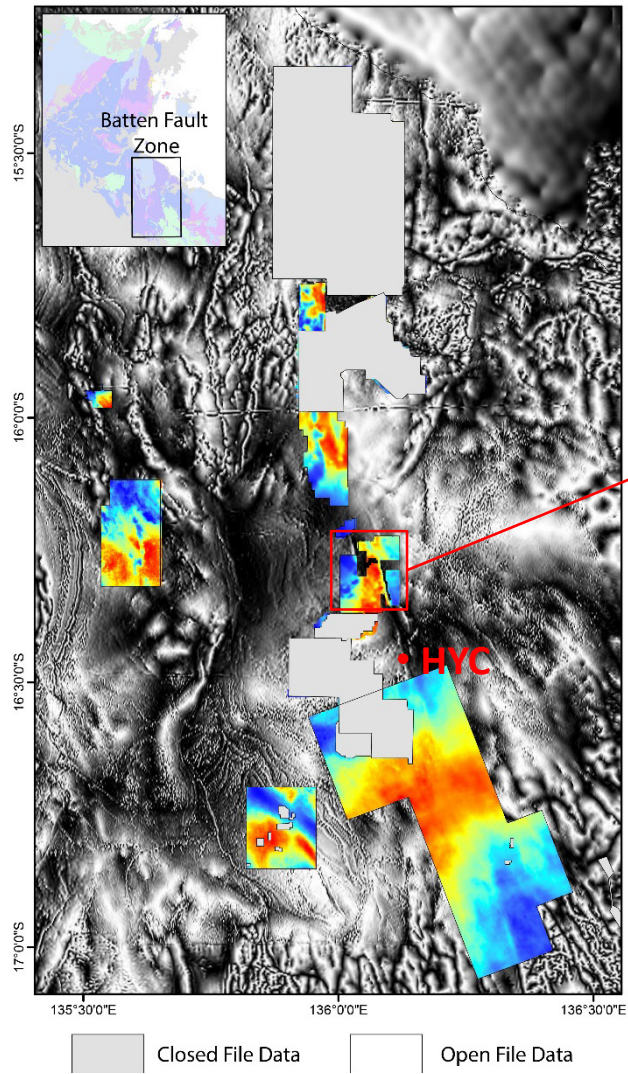
Case-study - Caranbirini

- Gravity and AEM
  - Structural features, including faults and folds
  - Different formations within the McArthur Group

- Radiometrics
  - Different formations within the McArthur Group

- Magnetics
  - Images depth to volcanics – not really useful for local scale interpretation

Legend

- Bukalara Sandstone
- Corcoran Formation
- Abner Sandstone, Hodgson Sandstone Member
- Abner Sandstone, Jalboi Member
- Abner Sandstone, Arnold Sandstone Member
- Crawford Formation
- Mainoru Formation
- Limmen Sandstone
- Balbirini Dolomite
- Smythe Sandstone
- Looking Glass Formation
- Stretton Sandstone
- Yalco Formation
- Lynott Formation, Donnegan Member
- Lynott Formation, Hot Spring Member
- Lynott Formation, Caranbirini Member
- Reward Dolomite

- Bedding formline
- Fault observed
- Fault interpreted from AEM
- Fault interpreted from AEM (uncertain)
- Fault interpreted from Aeromagnetics
- Anticline
- Syncline

Case-study - Caranbirini

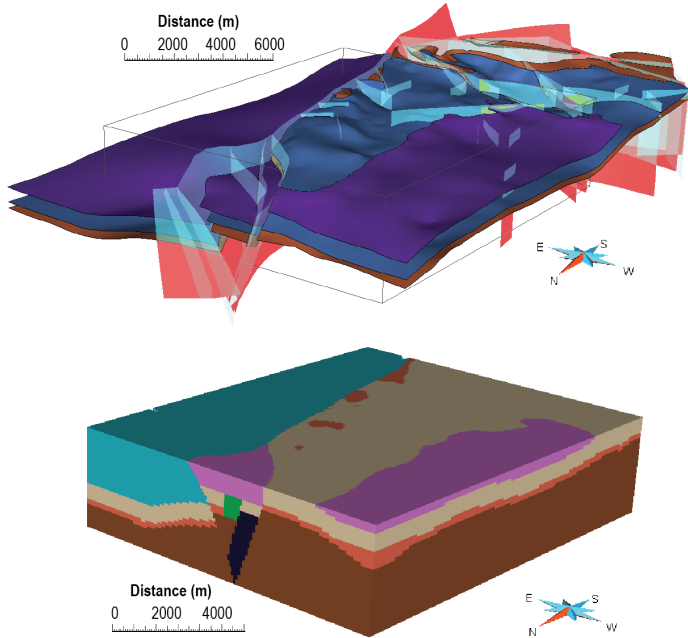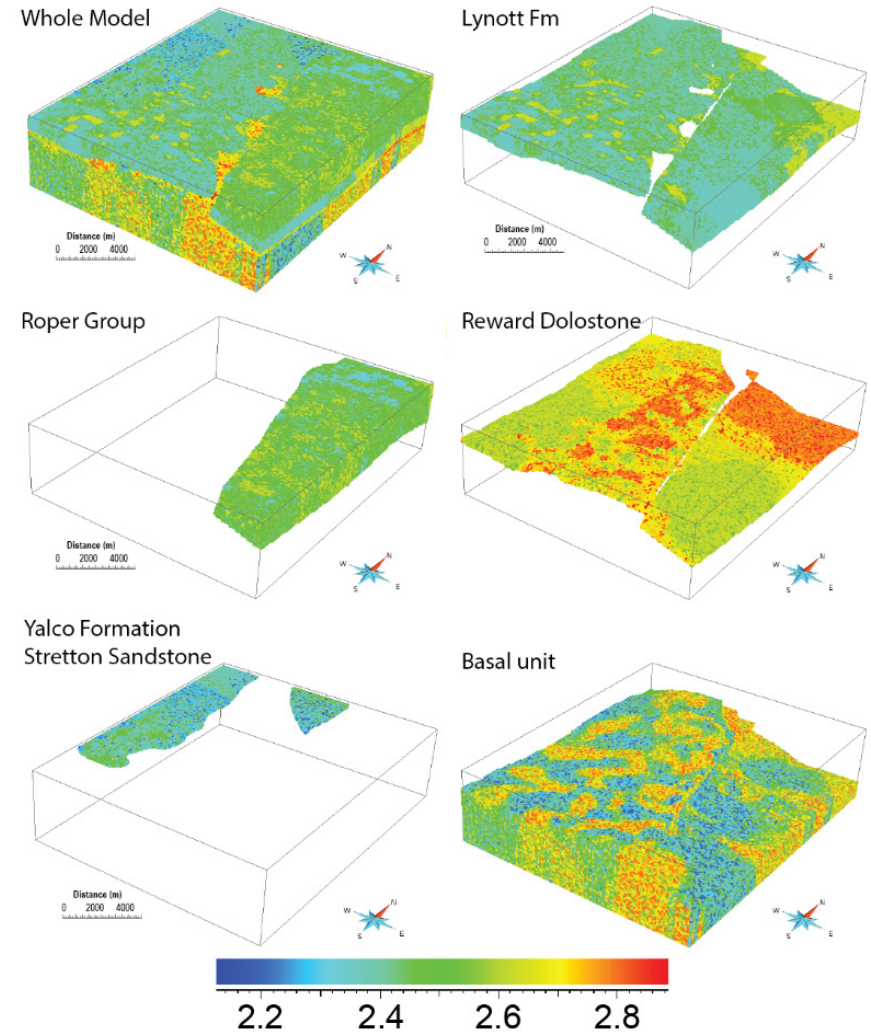- 3D model populated with density values (DIP013)

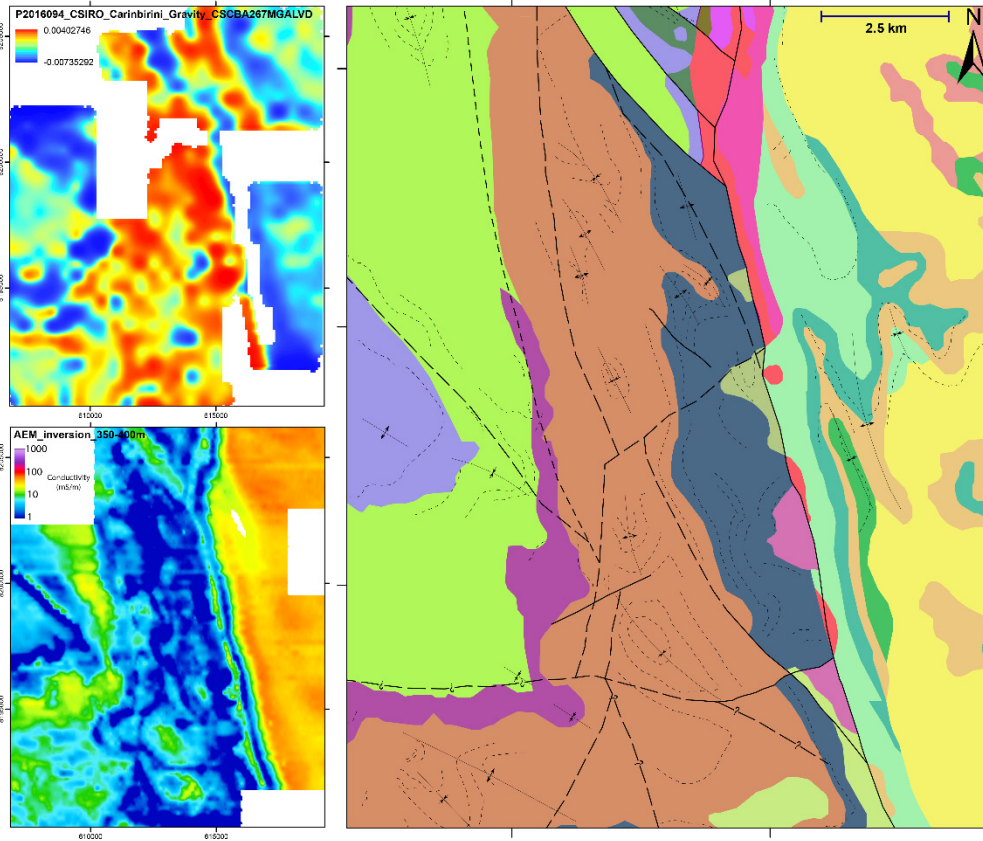- Inversion calculates density distribution within model
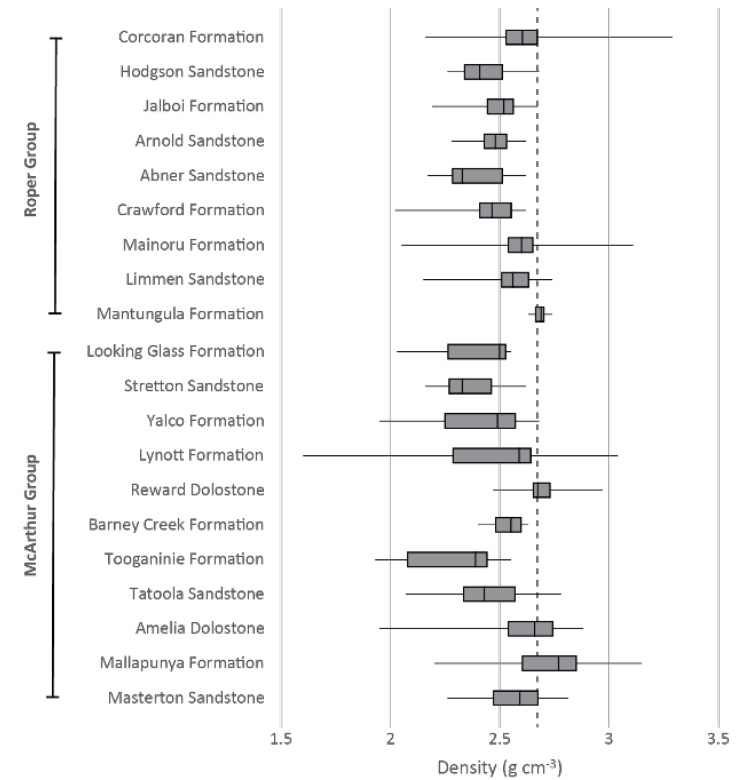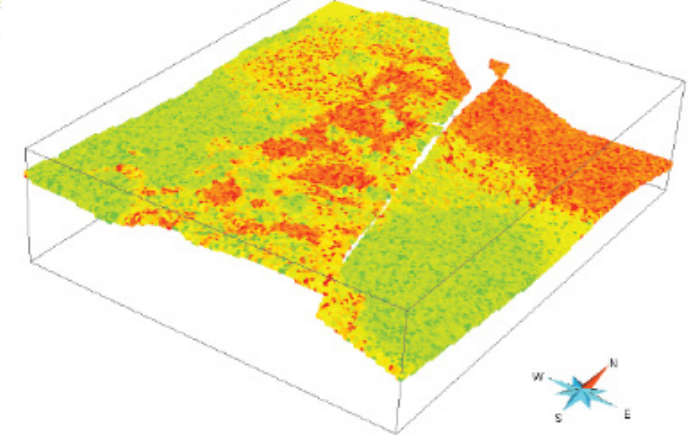
Case-study - Caranbirini

- Model geometry not allowed to vary

- Anomalous density concentrations indicate structural problems with model

Case-study - Caranbirini

Reward Dolostone

Possible geological models

Growth fault

Inverted stratigraphy

Graben
Syn-depositional faulting
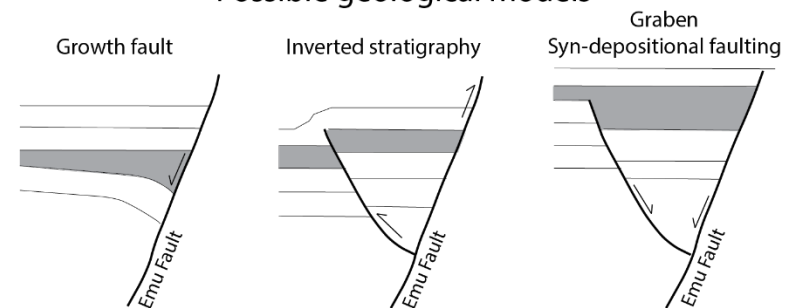
Value of high-resolution surveys and local case studies
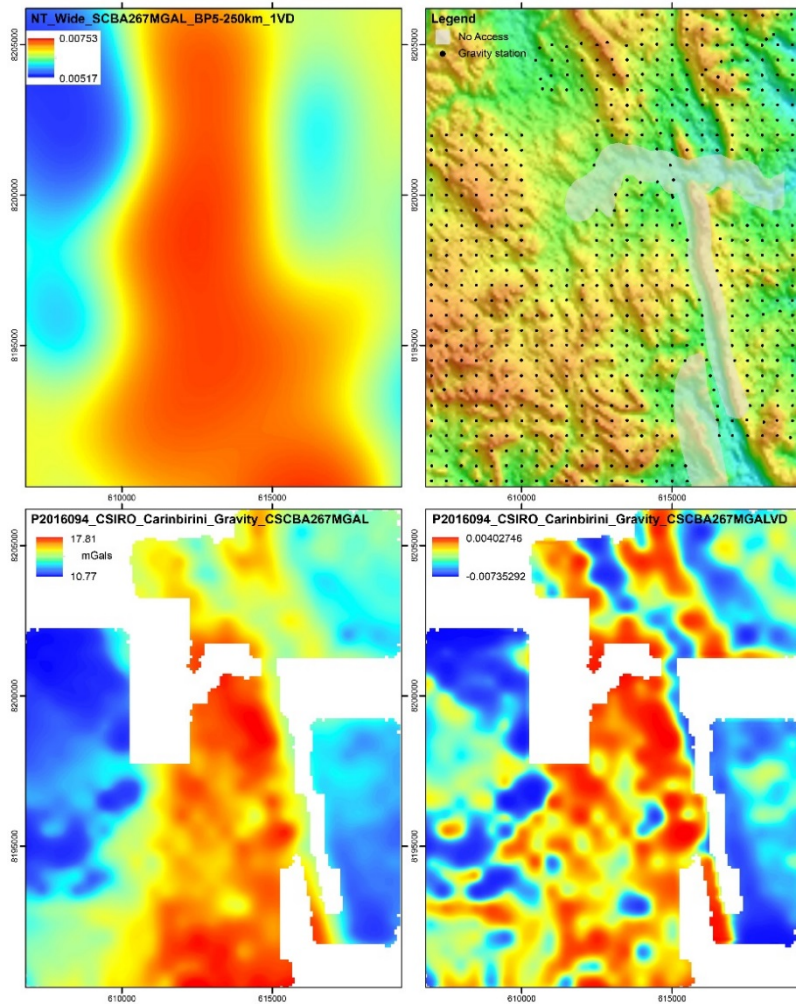
- Indicates minimum resolution required to adequately interpret and model subsurface geology

- Indicates value of complementary geophysical studies (AEM)

- Integrating interpretation of different geophysical and geological data has the capability of improving the understanding of:

  – Structural architecture

  – Sub-basin development within the McArthur Group

- Value in integrating this work with detailed stratigraphic correlations

Summary - Data Interpretation

- **Project aim: Improve understanding of the 3D structural architecture of the greater McArthur Basin through the analysis and interpretation of geophysical and geological data**

- Assessed available data, determined what can be achieved with it, and its limitations..

  - **Gravity**

    - Regional data (4 km) reasonably good for interpreting which package is likely to be present.

    - Local high-res company data is good for interpreting different formations within the McArthur Group.

  - **Magnetics**

    - Good for interpreting faults, and extent/depth to the Tawallah group. Subtle magnetic anomalies (in processed data) allow interpretation of different units within the Roper Group.

  - **Radiometrics** (where there is outcrop)

    - Good for interpreting the extent of different depositional packages, and can be used to interpret different formations in some areas.

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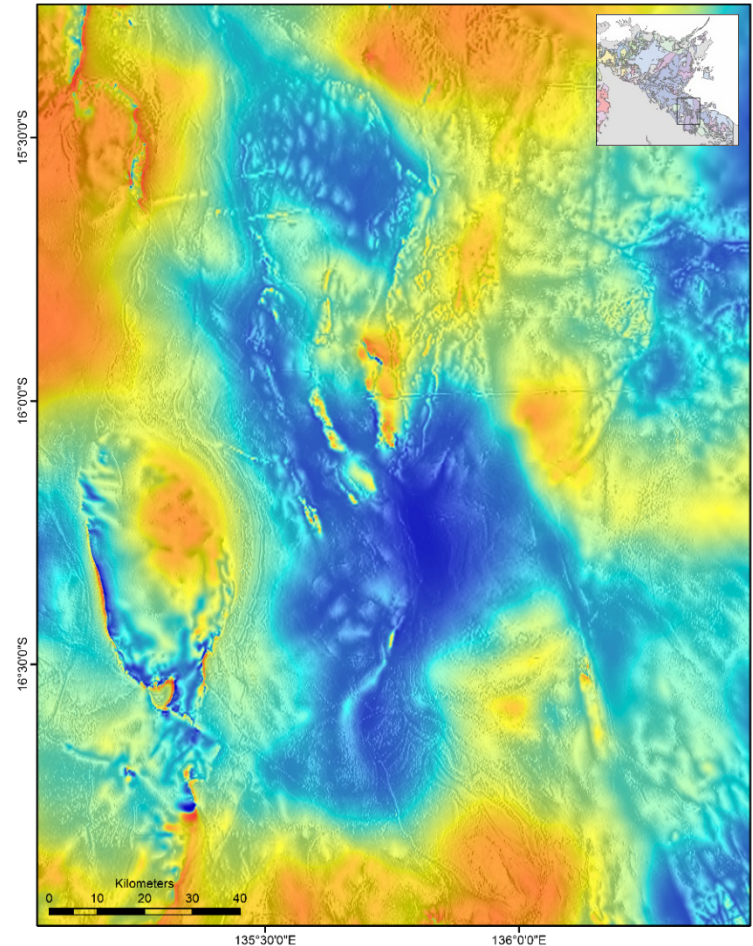
Architecture of McArthur Group
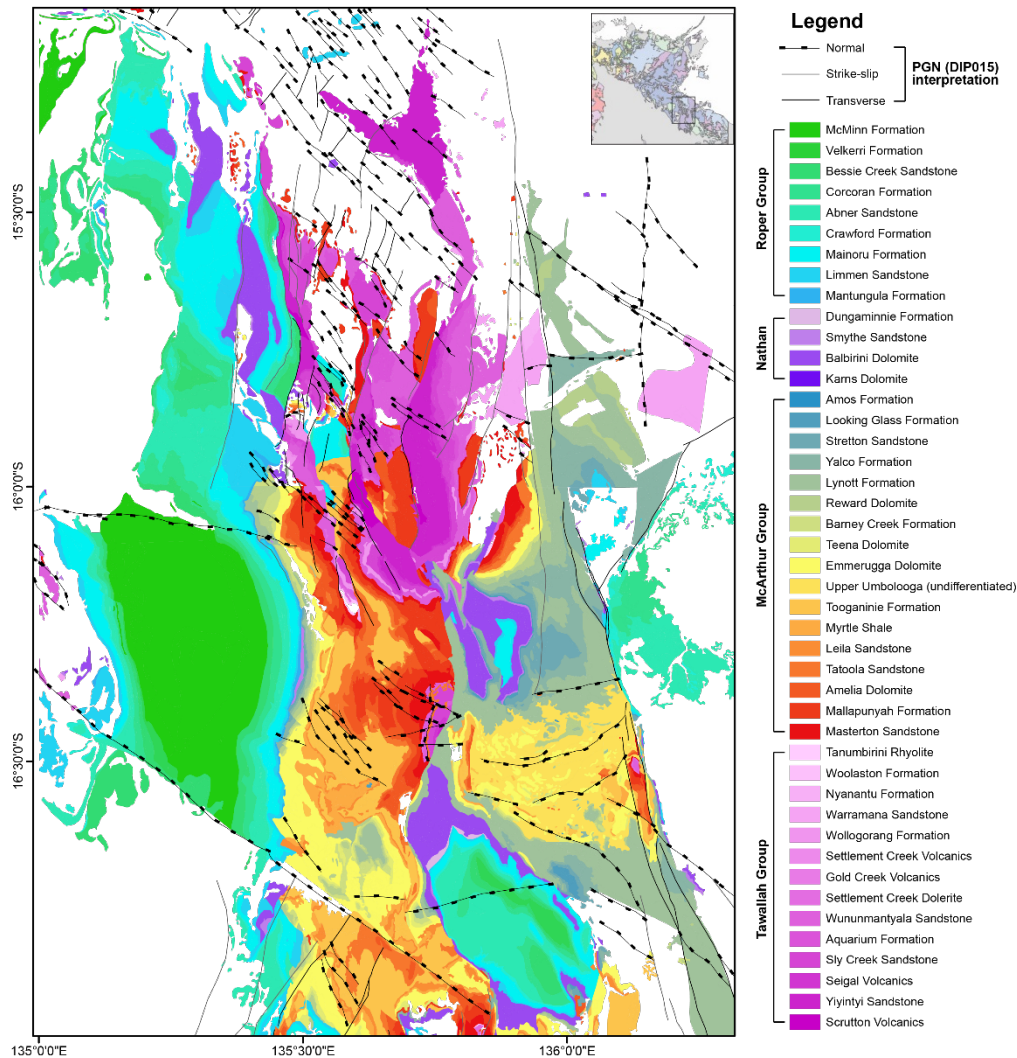
- McArthur Group controlled by:

  - **PGN interpretation (DIP015):**

    – NW-SE Normal & N-S transverse faults. NE-SW directed extension.

      – Interpretation holds for now

        - More work needed to understand influence of E-W faults

    – Does appear to some growth against N-S structures

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Thank you

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References

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Blaikie, T.N., Betts, P.G., Armit, R.J., and Ailleres, L., 2017, The Ca. 1740–1710 Ma Leichhardt Event: Inversion of a Continental Rift and Revision of the Tectonic Evolution of the North Australian Craton. *Precambrian Research* 292, 75-92.

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Dhu T, 2016. Gravity map of the Northern Territory, 1:2 500 000 scale. Northern Territory Geological Survey, Darwin.

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