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Geological interpretation of the regional Pine Creek airborne electromagnetic survey

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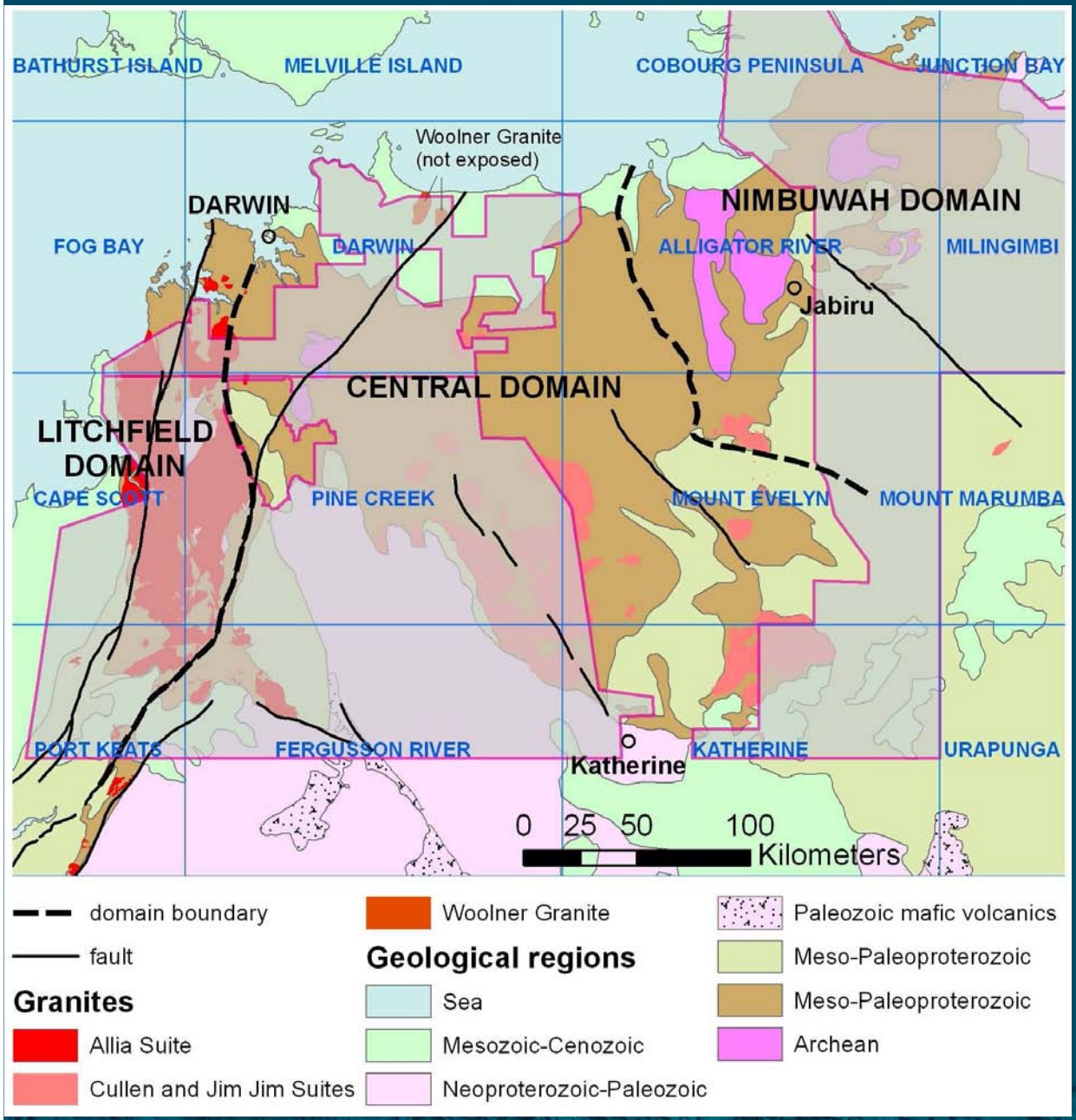


Pine Creek AEM survey

Western Pine Creek region

- Woolner Granite – Rum Jungle surveys
- Fugro TEMPEST™ system
- GA–LEI conductance estimates

Eastern Pine Creek region

- Kombolgie survey
- Geotech VTEM™ system
- EM Flow™ conductance images

Regional AEM survey

- Mapping shallow subsurface geological features
- Depth and character of regolith cover
- Conductive Paleoproterozoic metasedimentary rocks
- Pine Creek AEM record to be published shortly

Paterson record

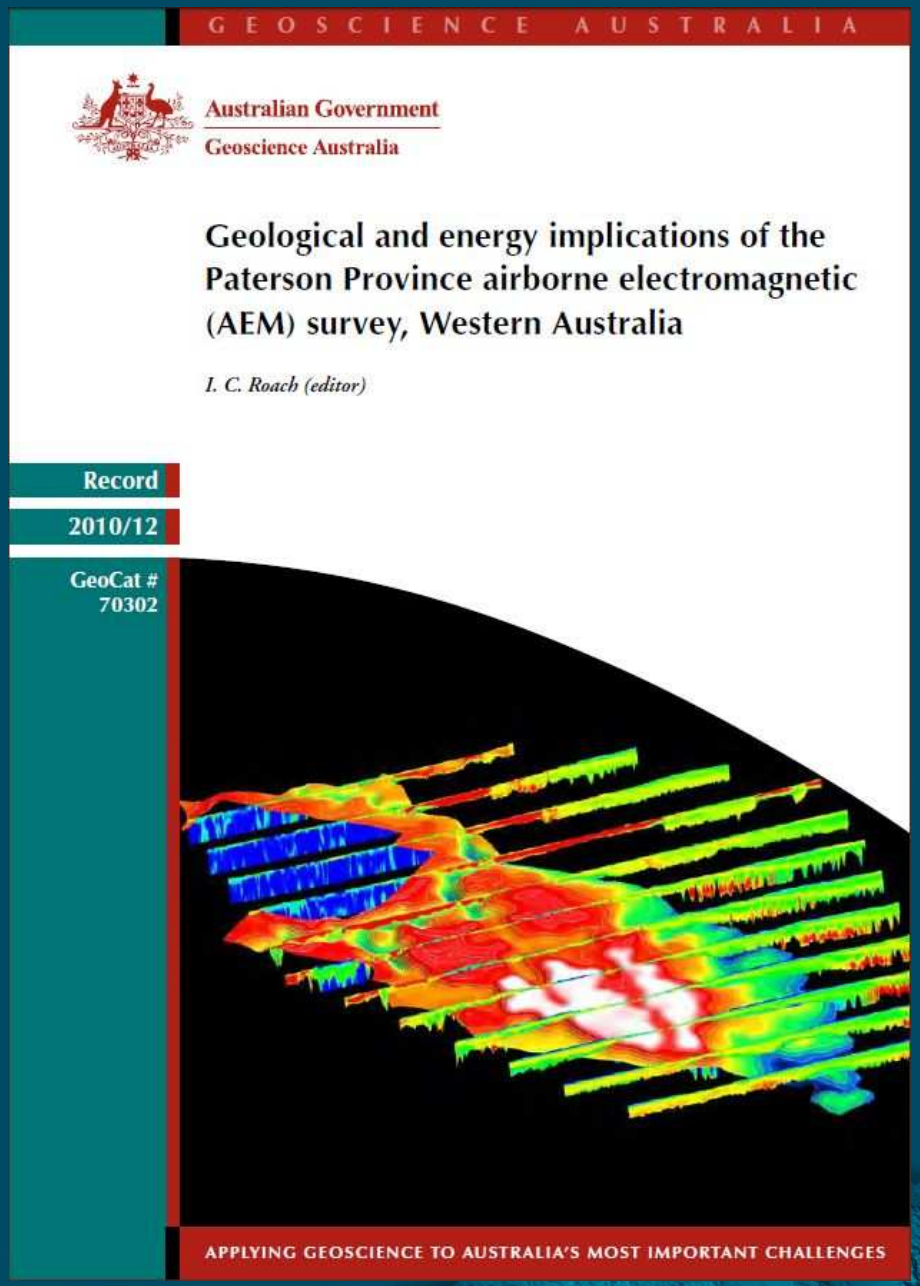
- Published in 2010
- Available in hard copies and pdf for free download from GA website

www.ga.gov.au

energy

projects

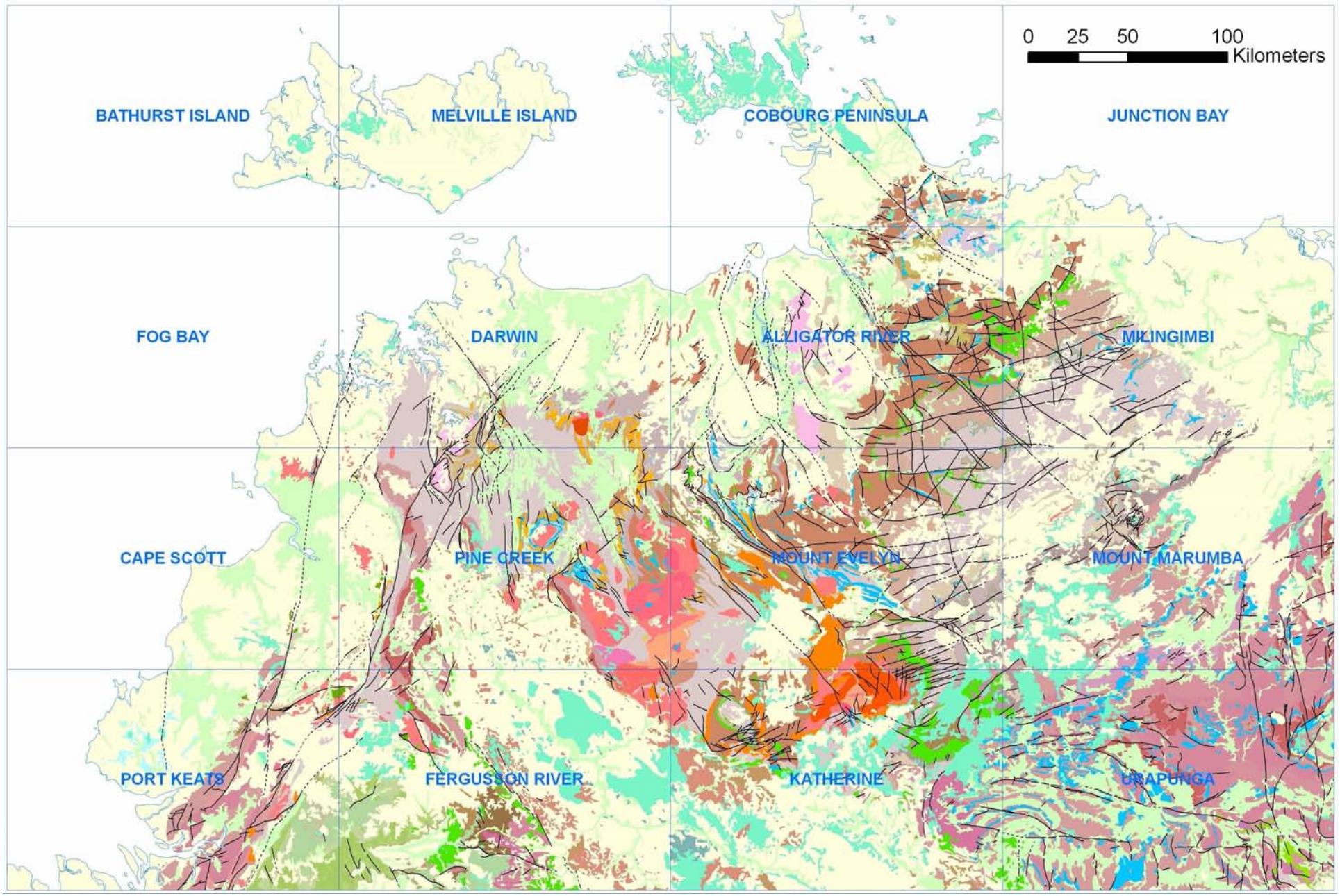
AEM



Data sets used in interpretation

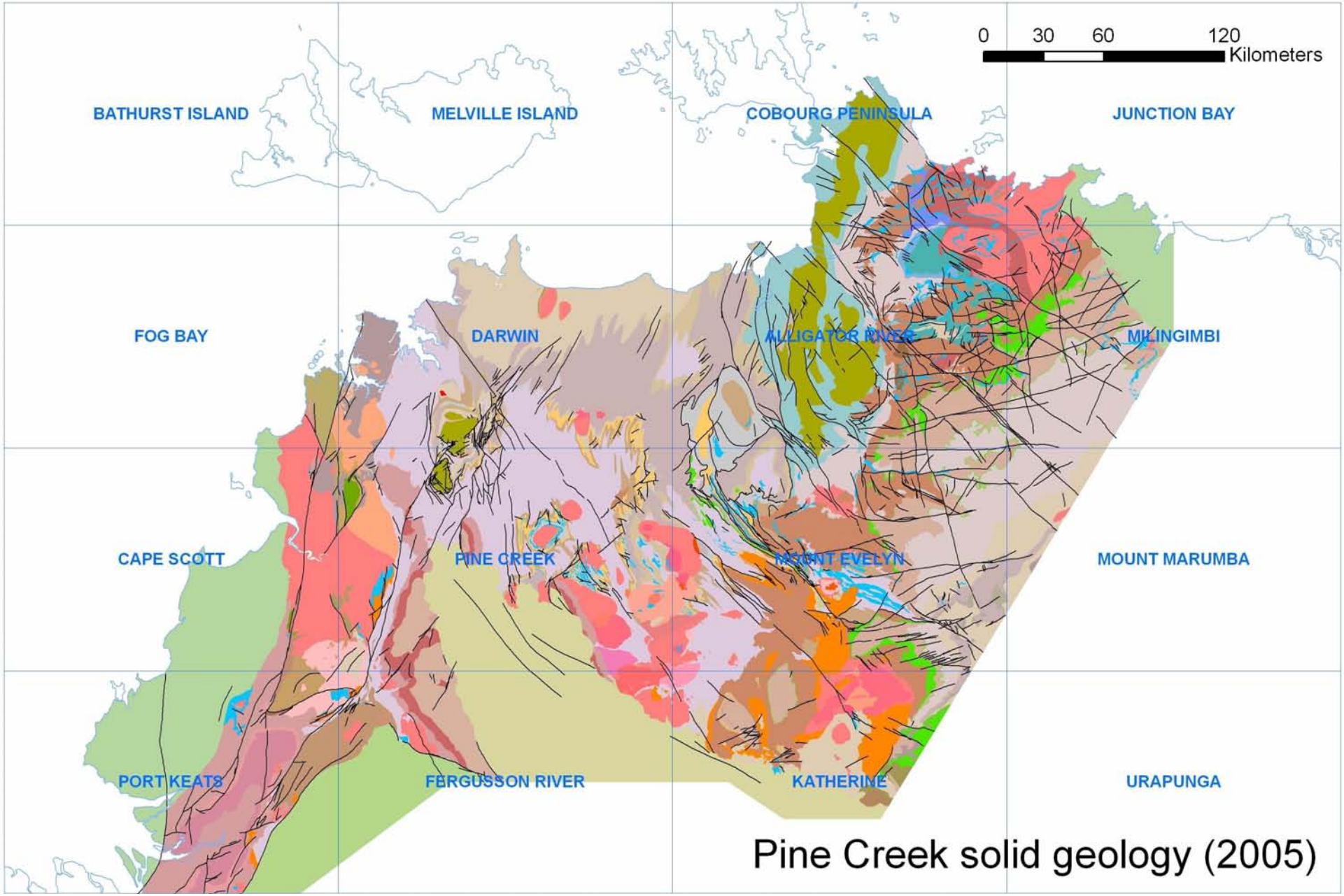
- Surface geology mapping
- Solid geology
  - NTGS 1:500k Pine Creek solid geology
  - new generalised basement geology
- Regolith geology
- DEM and satellite images
- Drill hole data

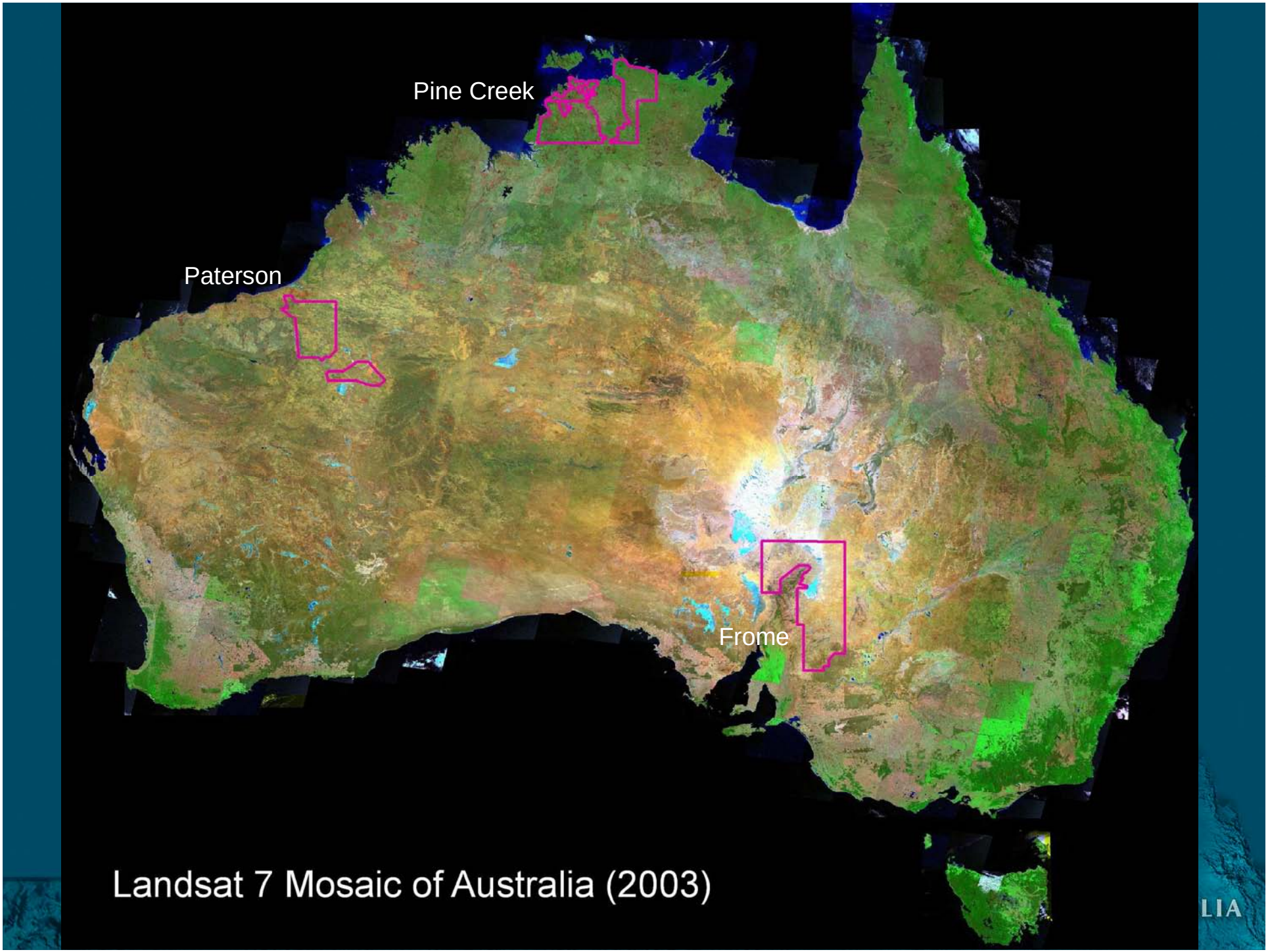
Surface geology of north NT (1:1 m)



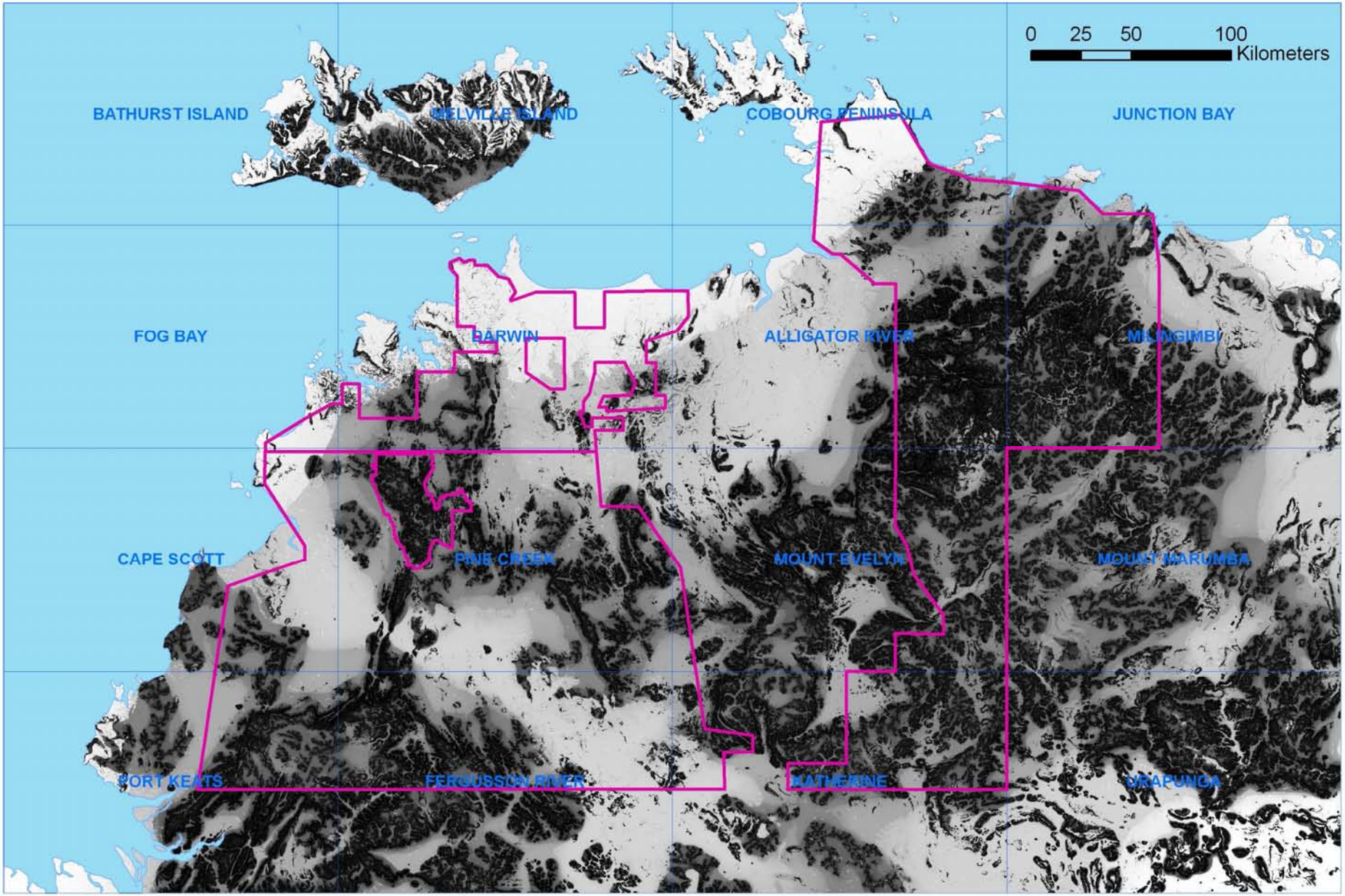
River crossing to Nabarlek

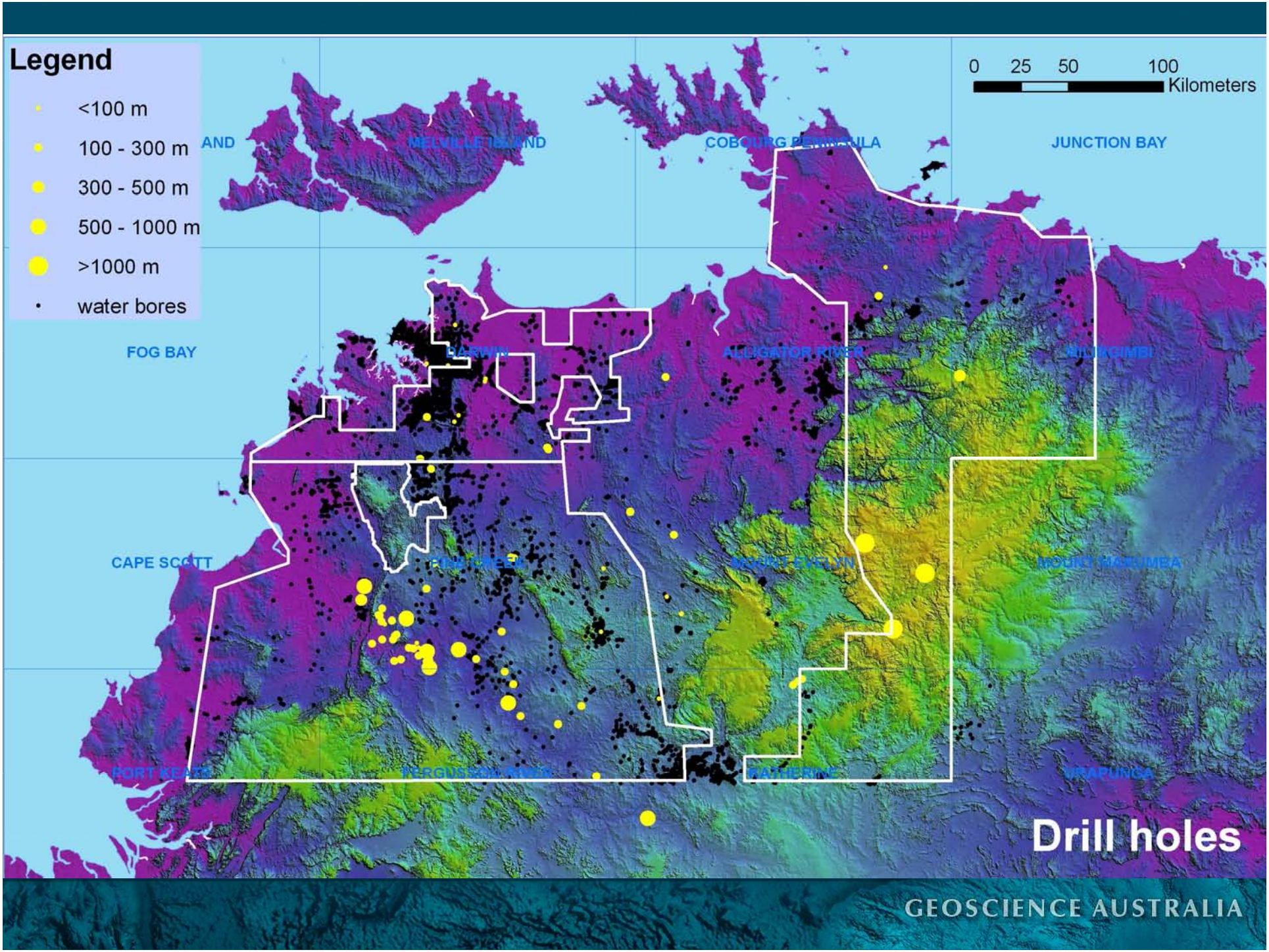
Pine Creek solid geology (NTGS 2005)




Pine Creek
Paterson
Frome
Landsat 7 Mosaic of Australia (2003)

DEM image: MrVBF (multi-resolution valley bottom flatness index)




Legend
<100 m
100 - 300 m
300 - 500 m
500 - 1000 m
>1000 m
water bores
0 25 50 100
Kilometers
AND
MELVILLE ISLAND
COBOURG PENINSULA
JUNCTION BAY
FOG BAY
DARWIN
ALLIGATOR RIVER
CAPE SCOTT
MOUNT EVELYN
MOUNT HARUMBA
PORT KEATS
FERGUSSON RIVER
KATHERINE
Drill holes
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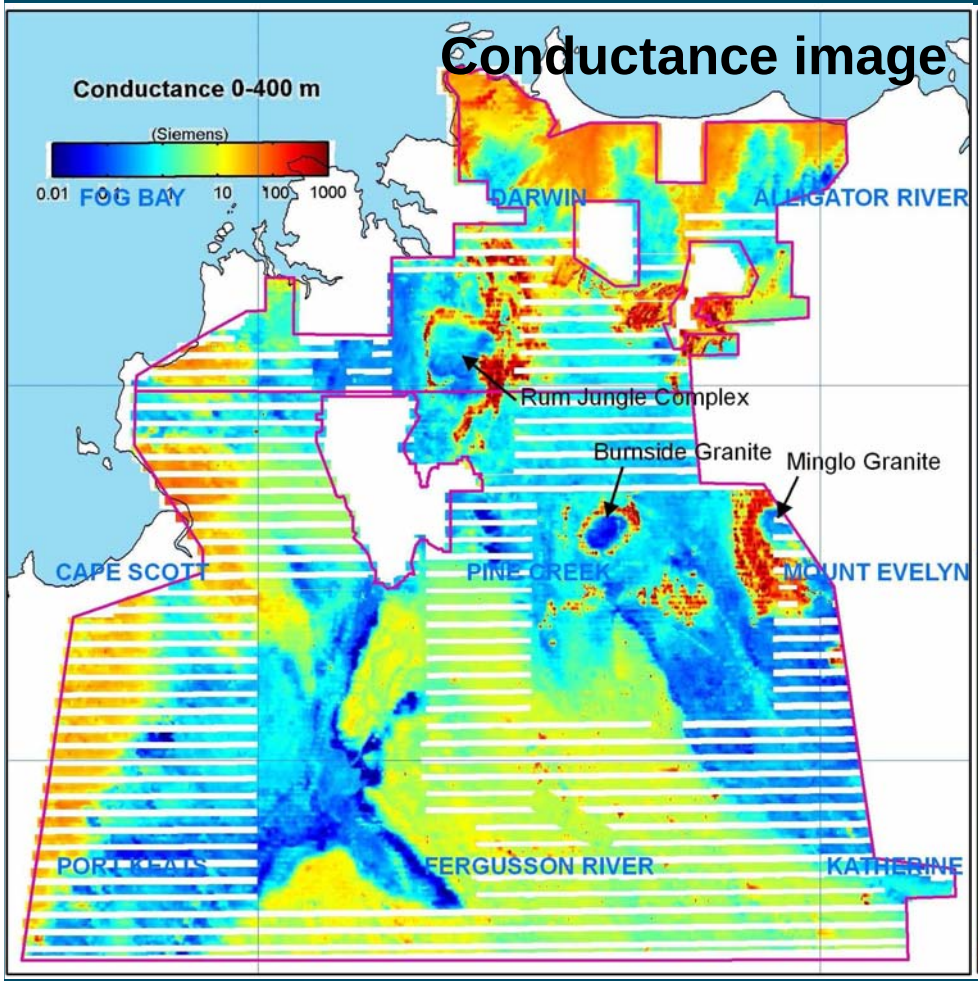
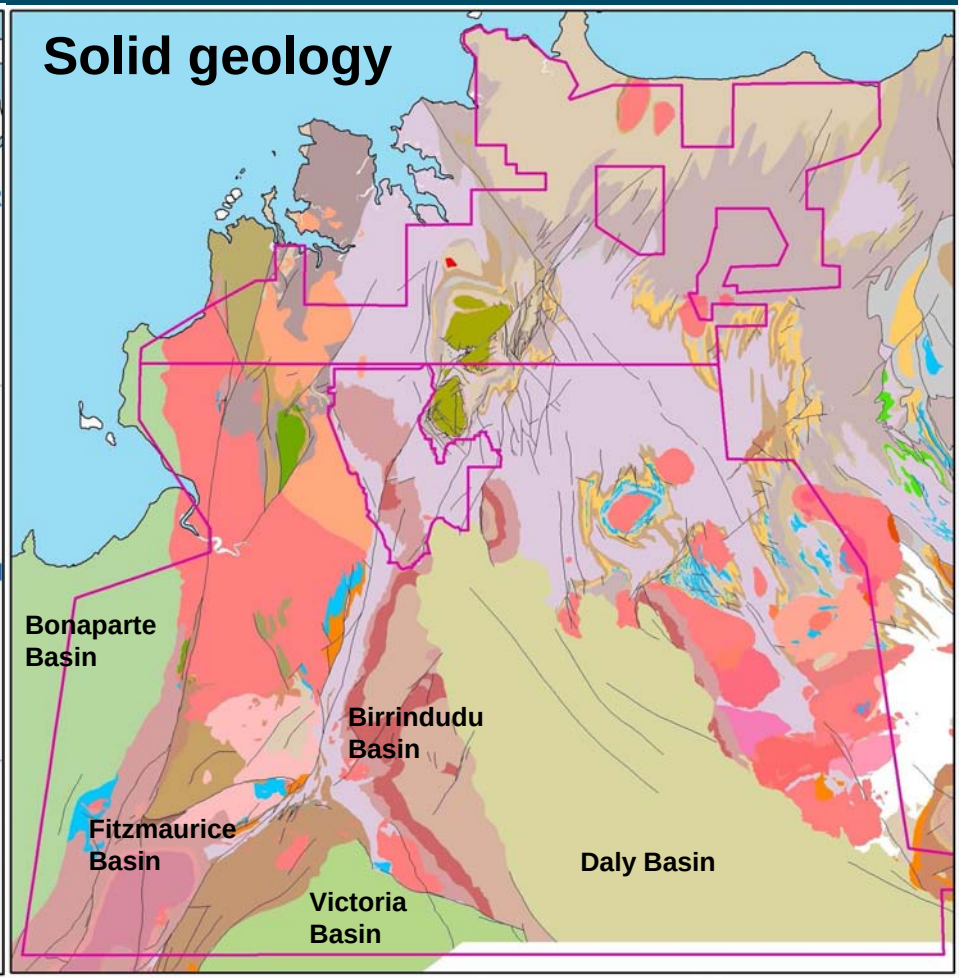
Ants nest

Woolner Granite – Rum Jungle surveys by TEMPEST™



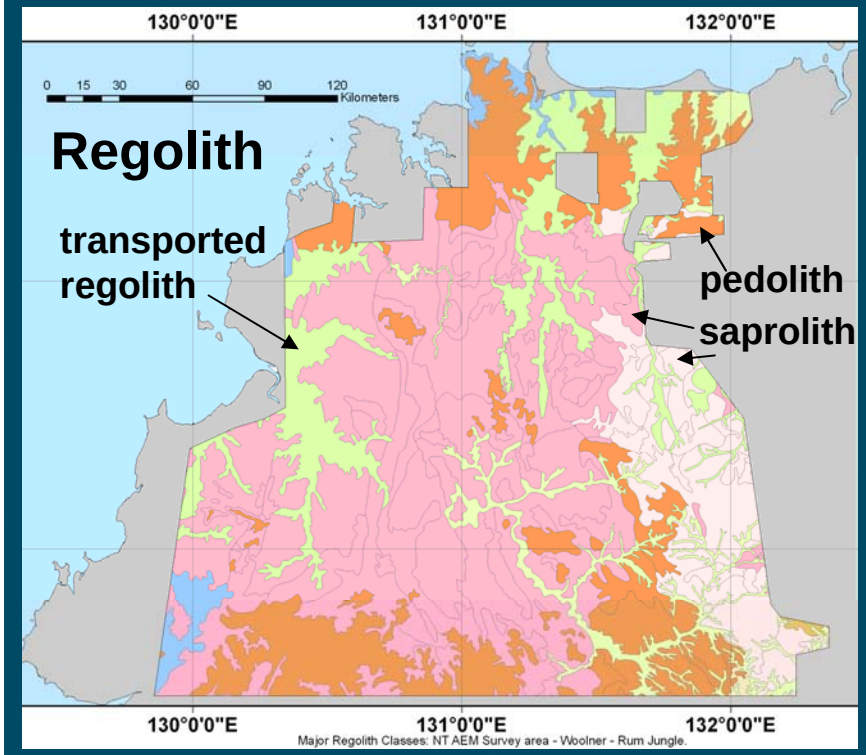


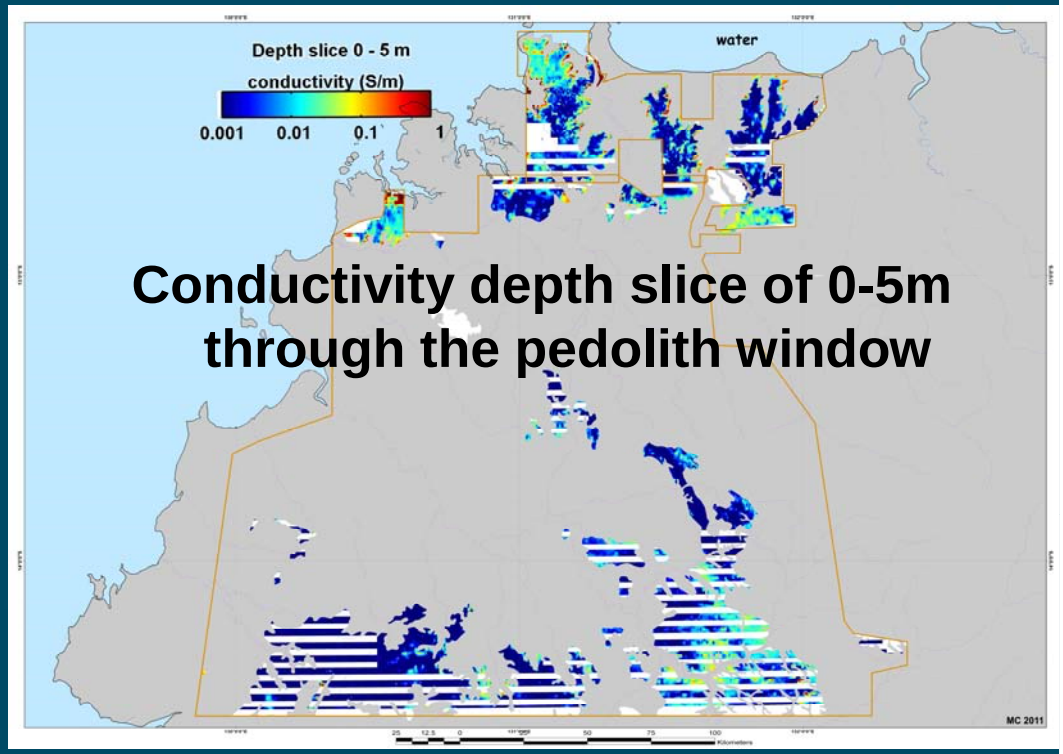
Strongly conductive: carbonaceous metasediments (Koolpin & Whites Fms), saline water

Weakly to moderately conductive: Victoria, Birrindudu and Daly basins

Resistive: Fitzmaurice Basin, much of the Pine Creek Orogen, granite

Western Pine Creek region





Regolith units:

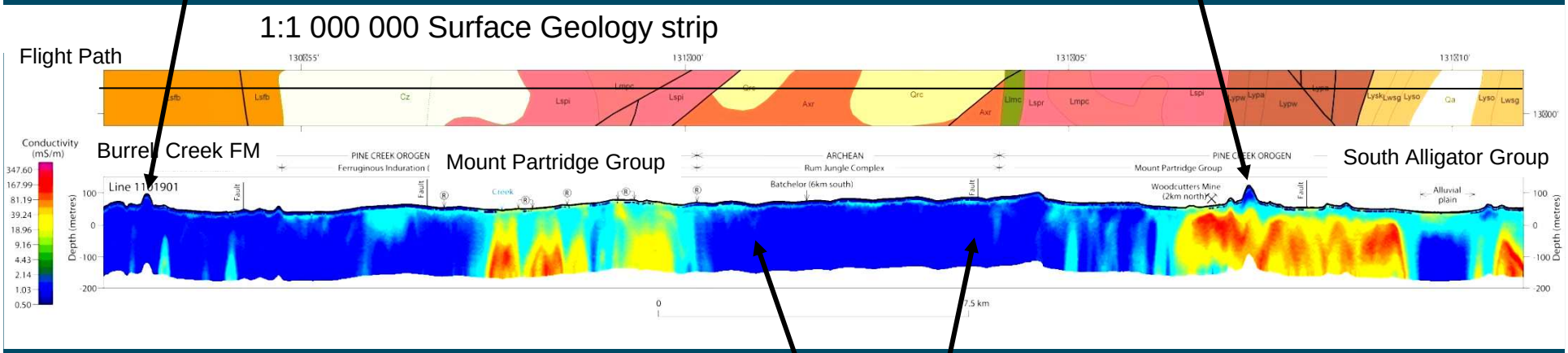
- transported regolith (= yellowish green) : mostly conductive nearer the coast, variable elsewhere
- pedolith (residual materials = brown) : resistive
- saprolith (saprolite & saprock = pink) : resistive (saprolite dominated) in upper parts of the landscape and may be conductive (saprock dominated) in lower parts

Weathering changes conductivity

Pedolith in GA-LEI cross-section

Pedolith: resistive

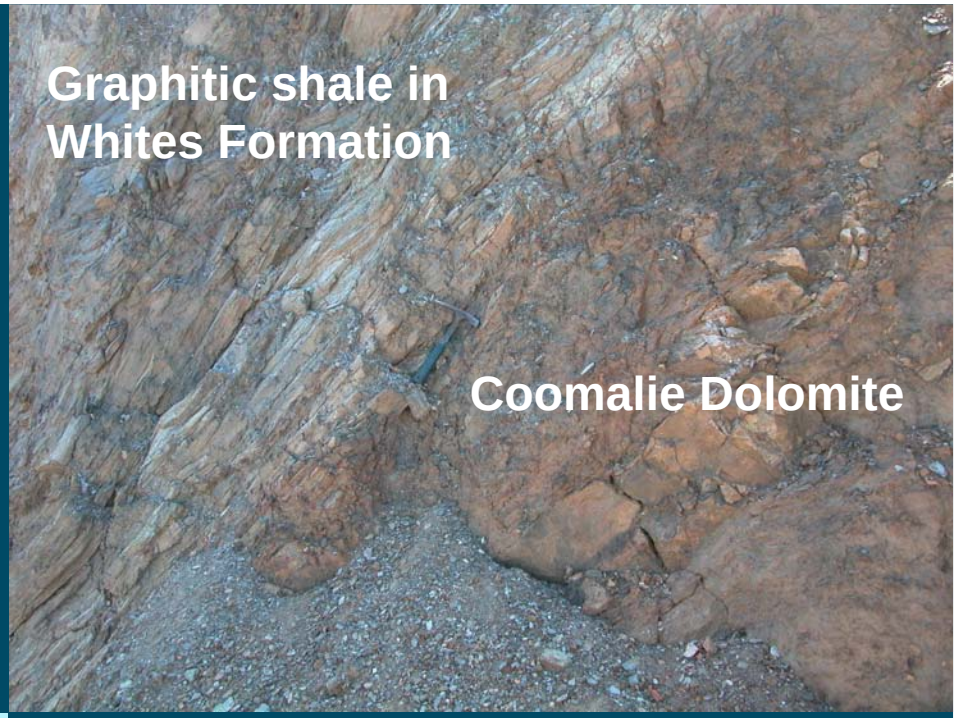
Pedolith: resistive



Rum Jungle Complex

Strong conductors in Pine Creek Orogen

- carbonaceous and pyritic sediments
- Koolpin, Whites & Cahill Formations



Browns Pit

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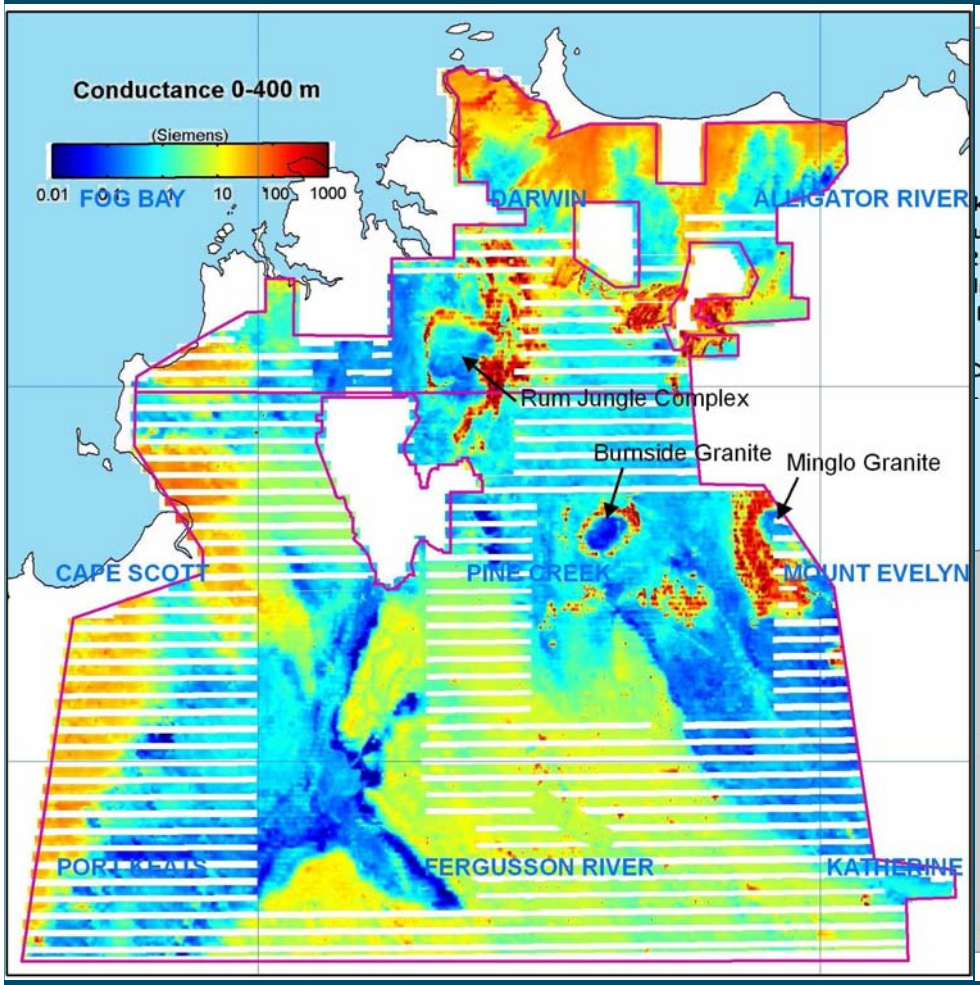
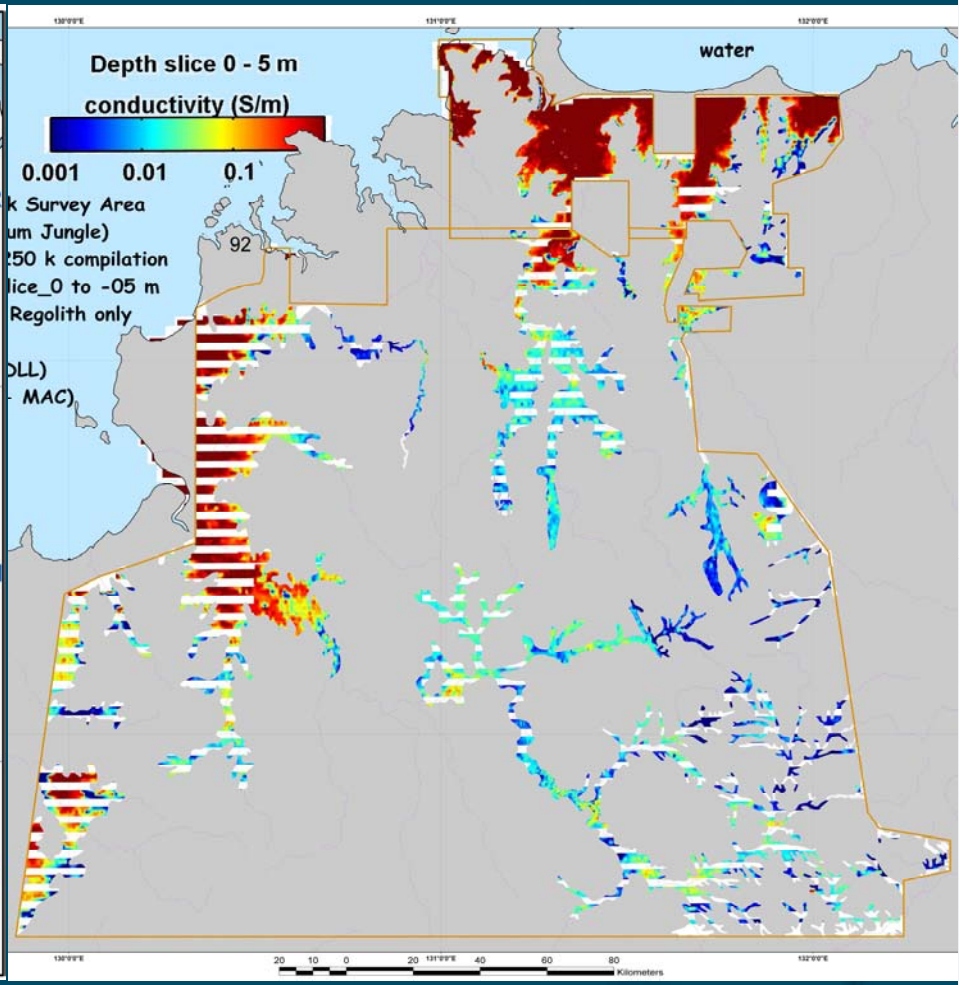
Saline water and conductivity

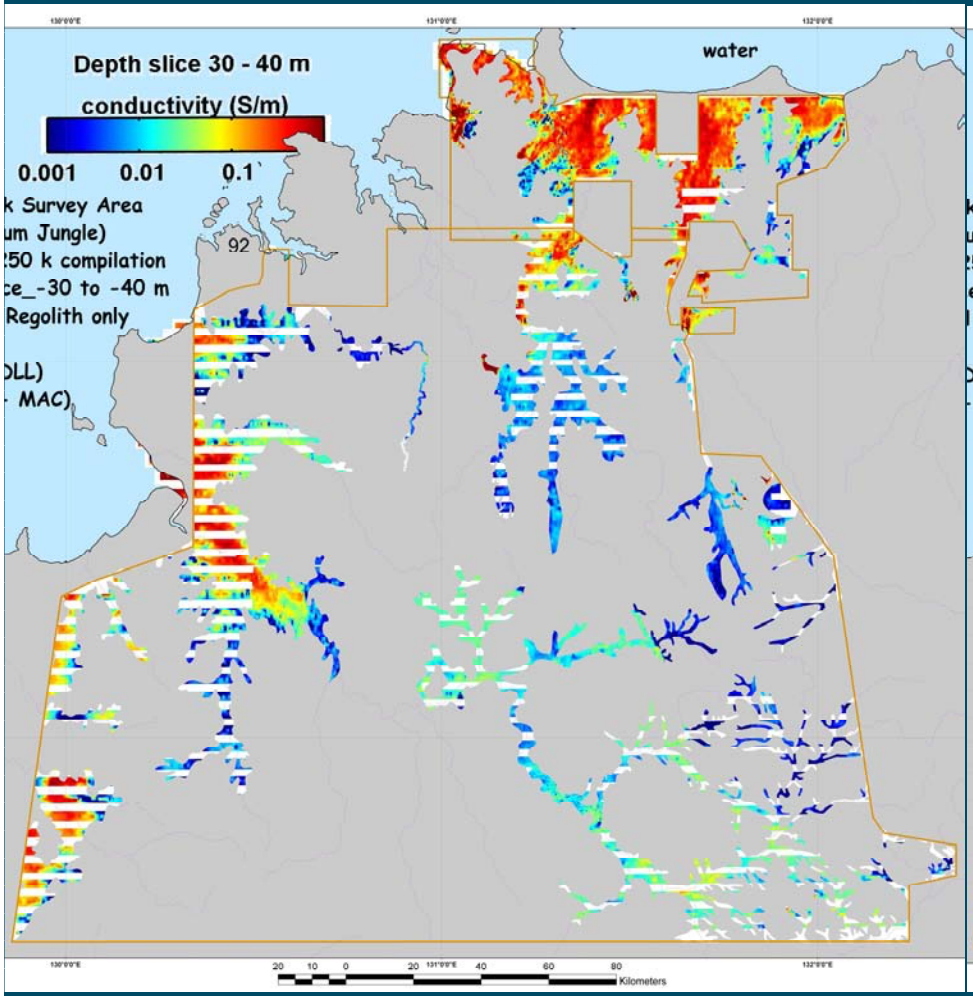


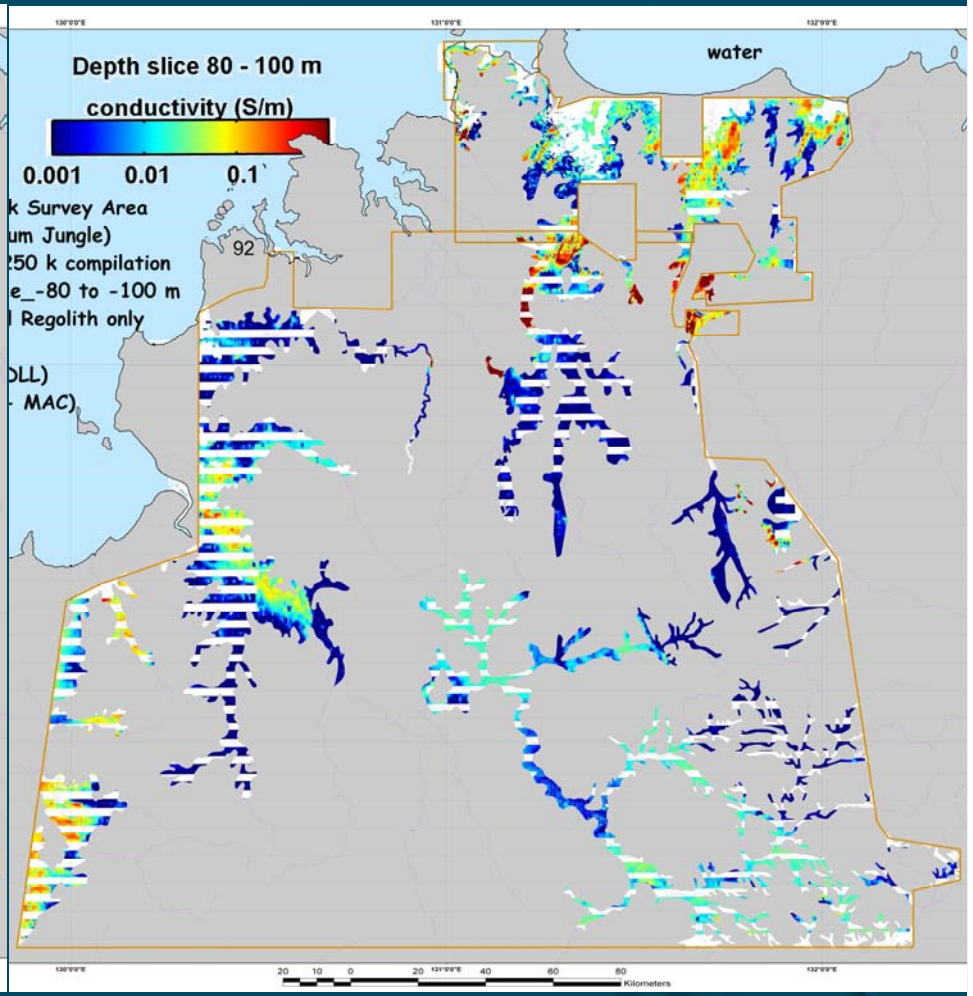


Conductance image

Conductivity depth slice: 0-5m through the alluvium & coastal regolith window

Saline water and conductivity





Conductivity depth slice: 30-40m **Conductivity depth slice: 80-100m**

through the alluvium & coastal regolith window

saline water effect on conductivity: ~ top 60 m

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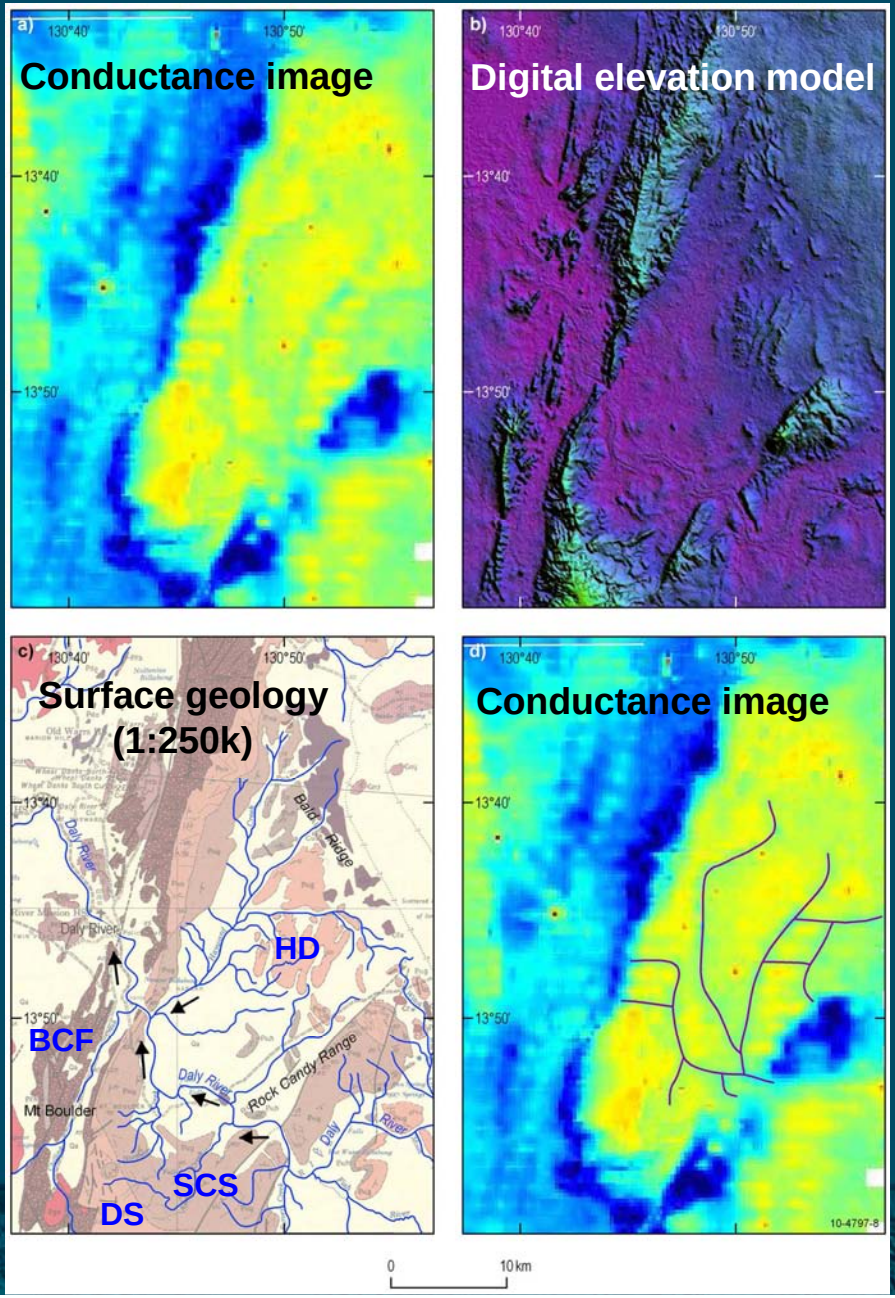
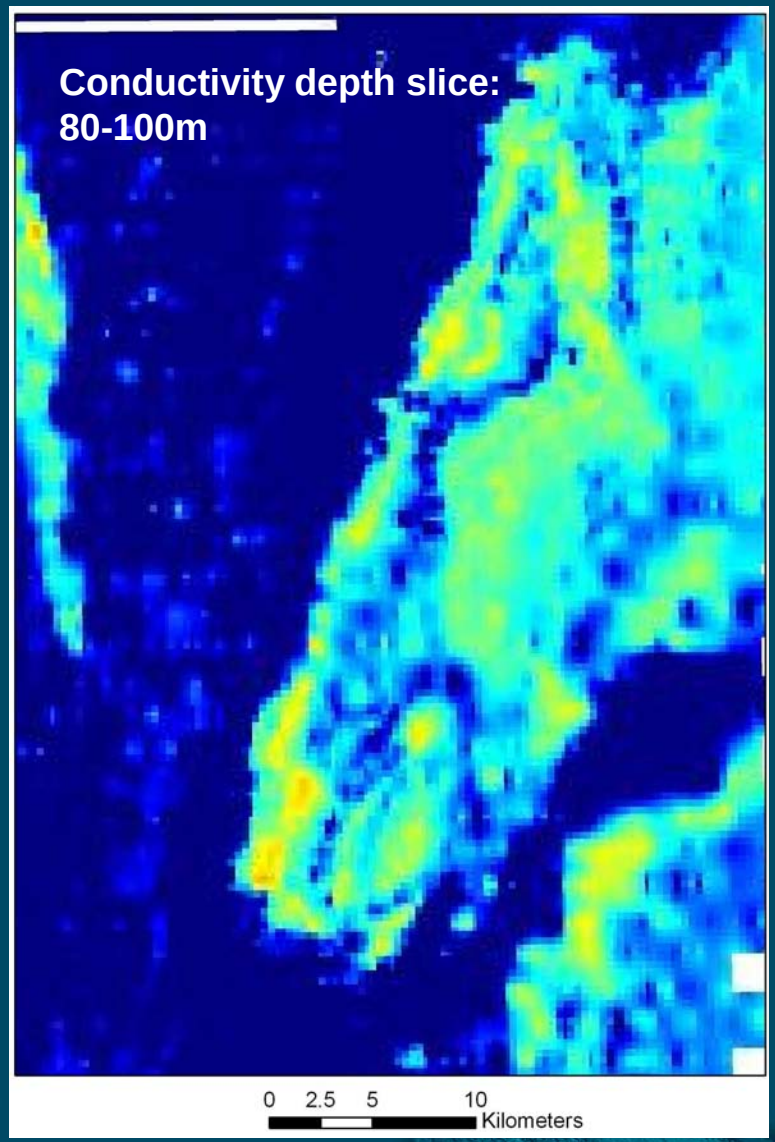
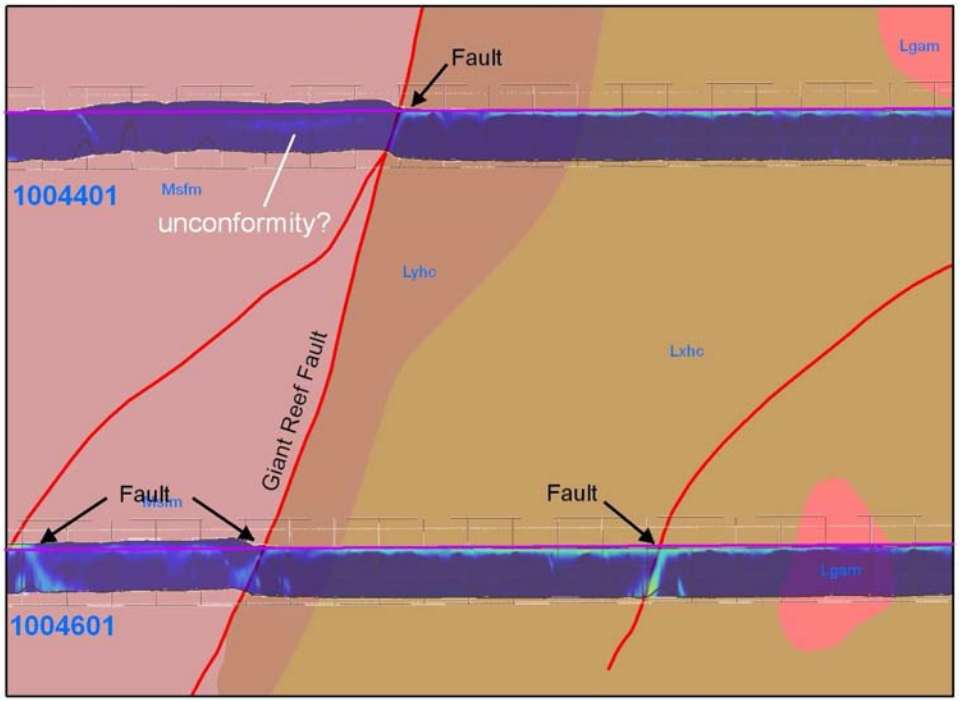
Mapping palaeovalleys with AEM





Mapping faults using AEM data

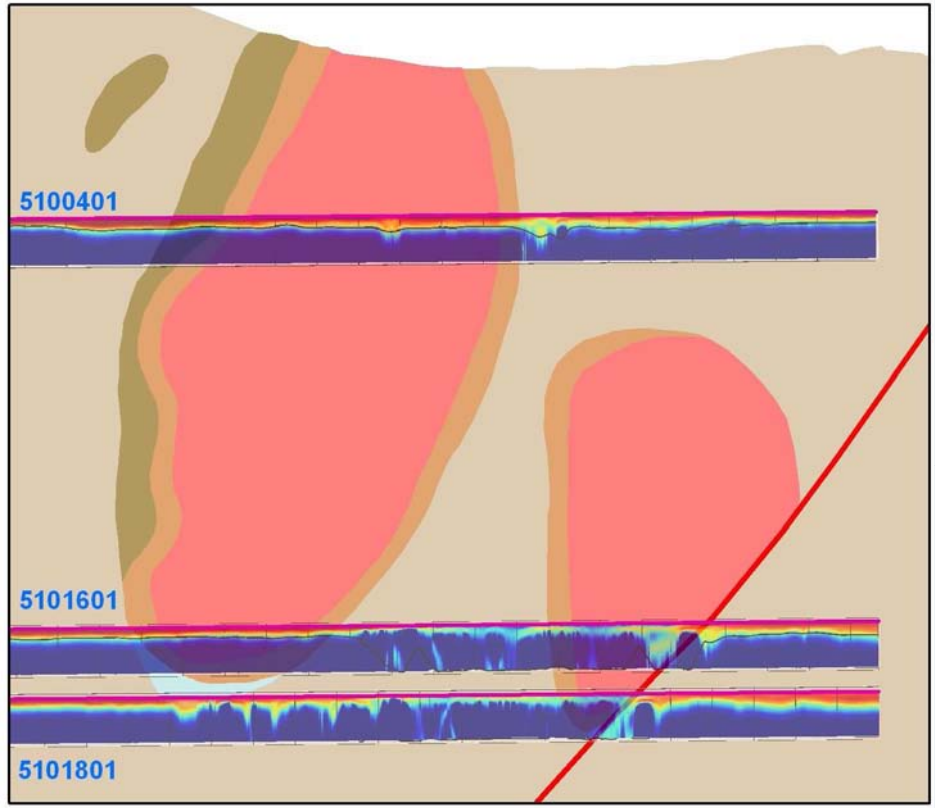


Legend

- Fault

Meso- to Paleoproterozoic

- Fitzmaurice Group
- Granite
- Hermit Creek Metamorphics (schist & gneiss)
- Hermit Creek Metamorphics (schist)



- AEM survey line
- Fault

Paleoproterozoic

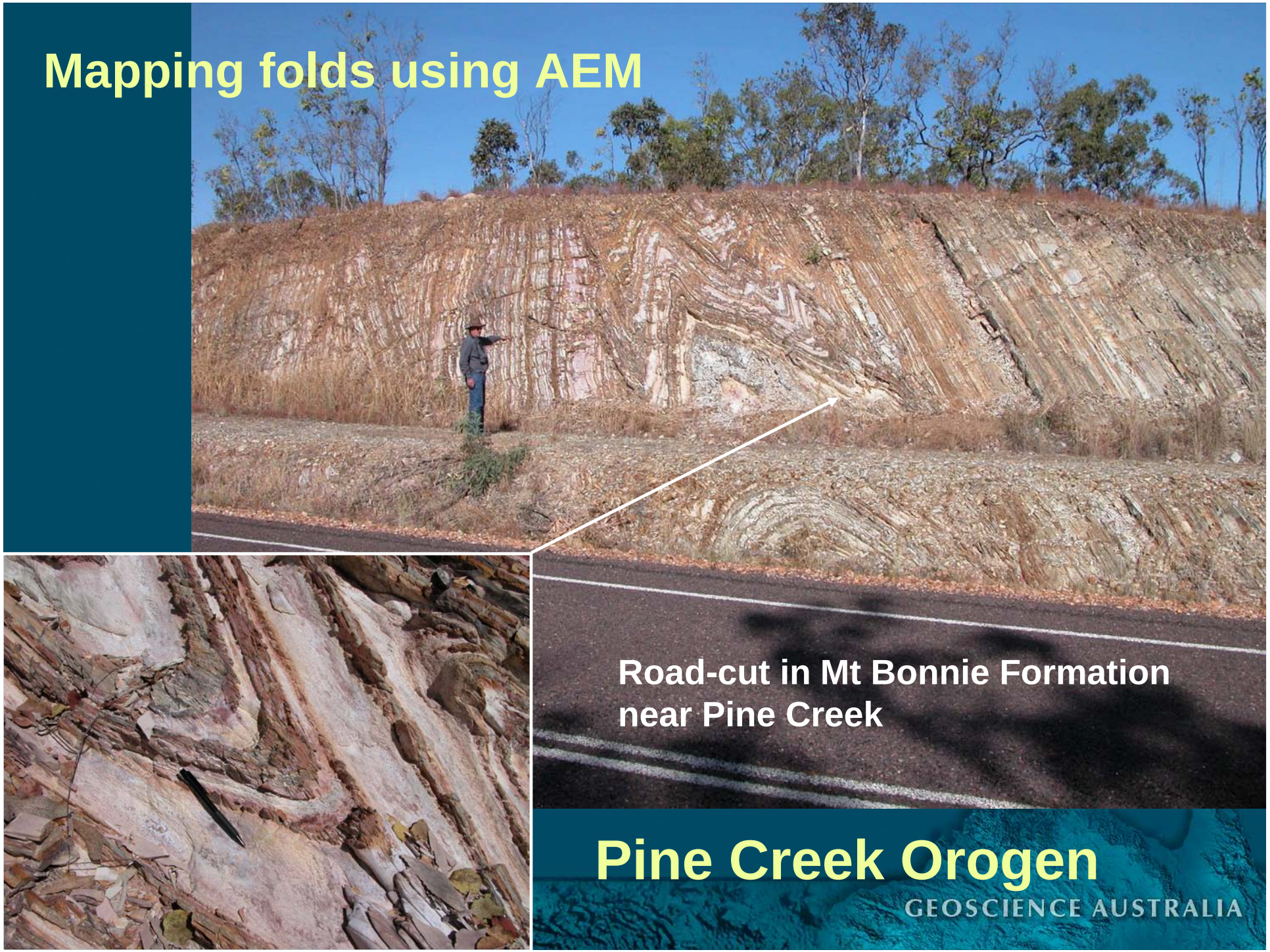
- Mt Partridge Group
- Koolpinyah Dolostone

- Dirty Water Metamorphics
- Dirty Water Metamorphics (gneiss)

Archean

- Woolner Granite

Mapping folds using AEM



Road-cut in Mt Bonnie Formation near Pine Creek

Pine Creek Orogen

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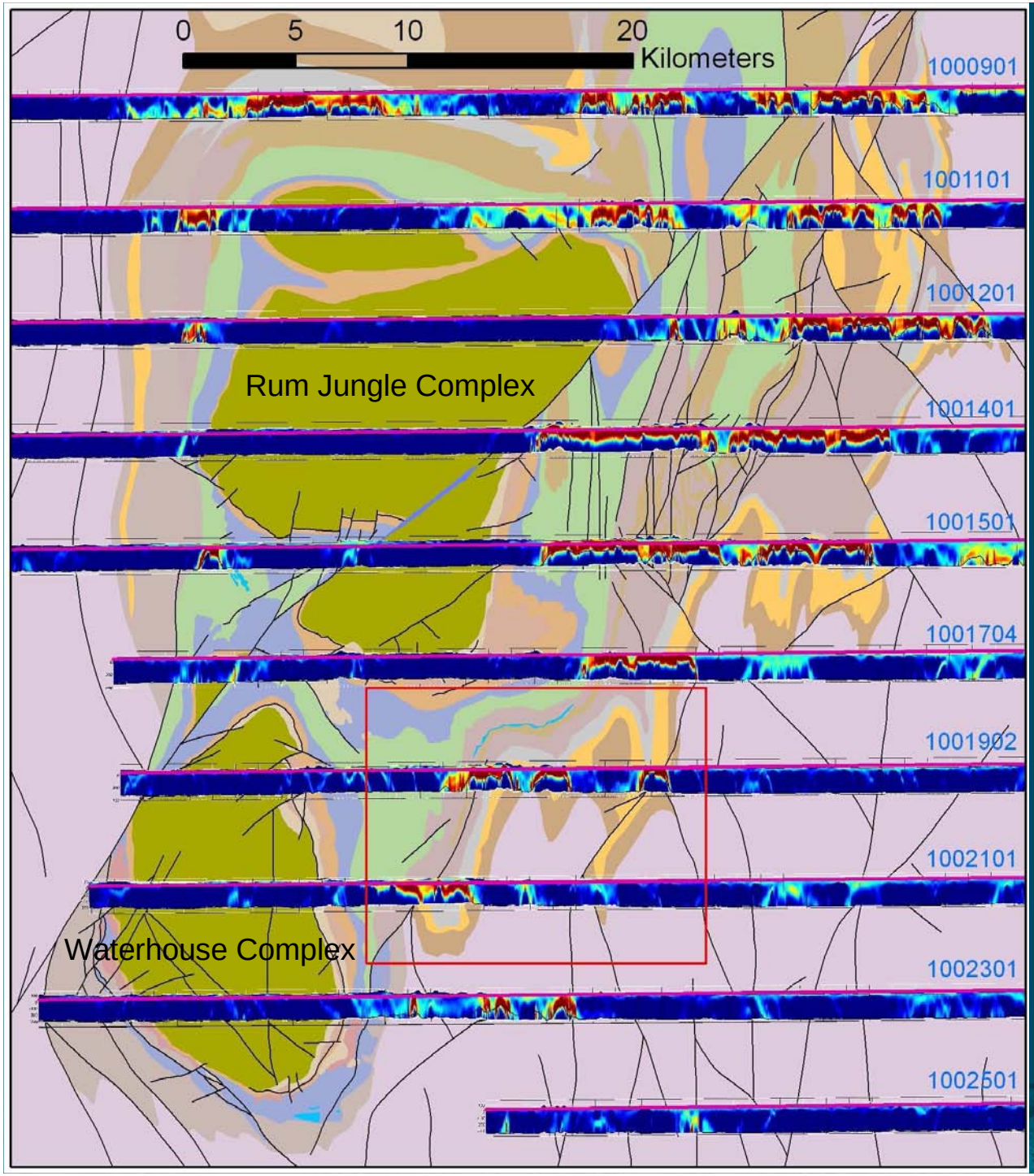
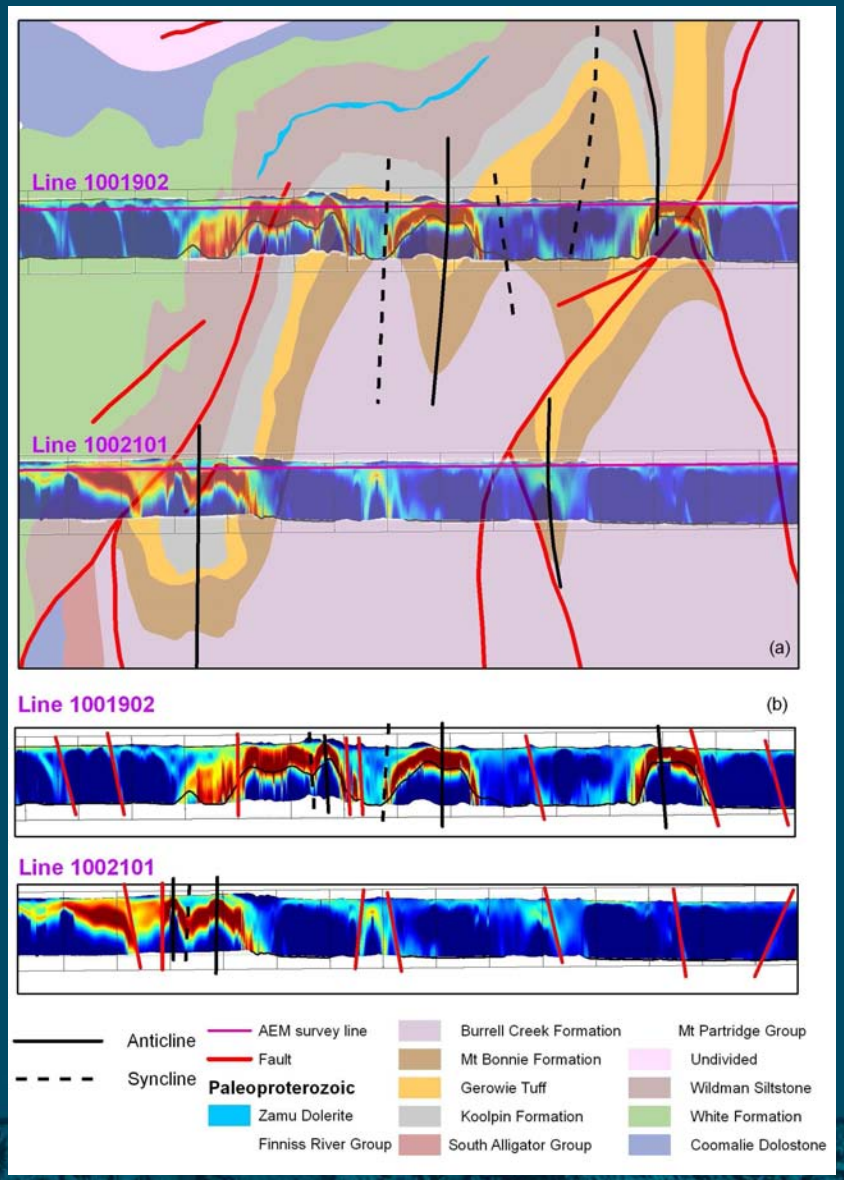
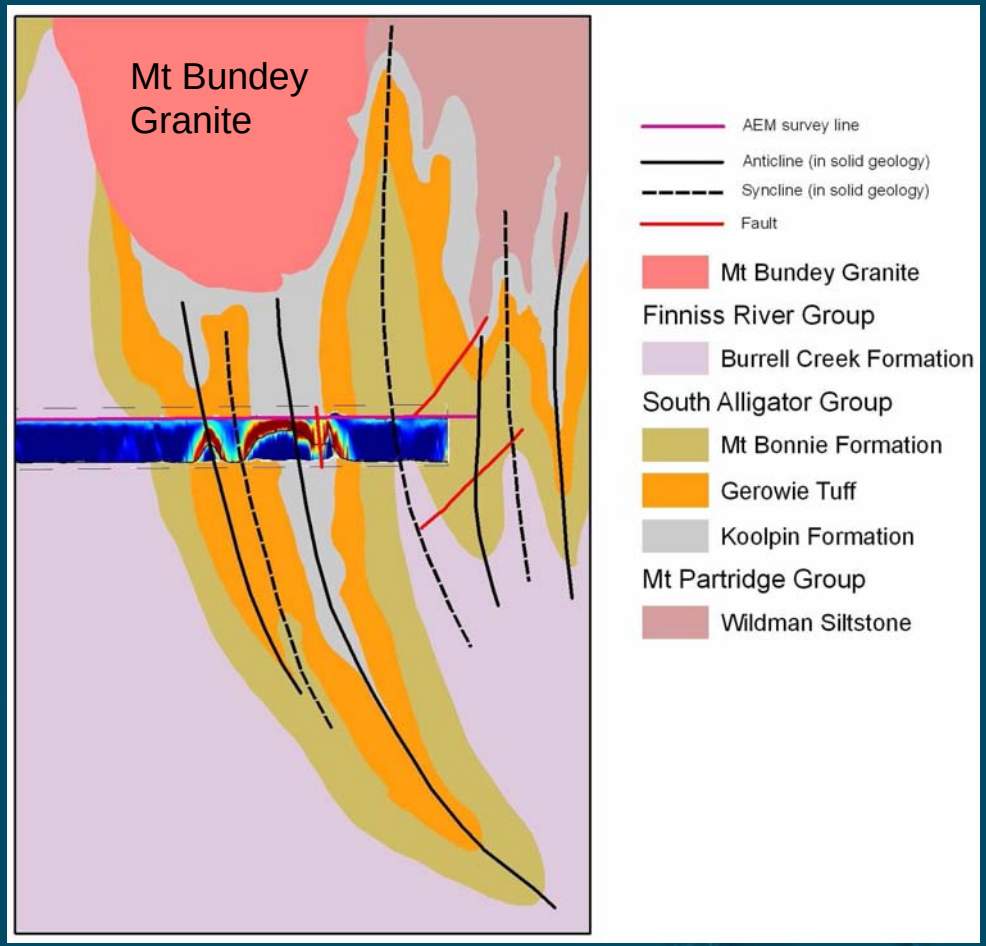


Rum Jungle area

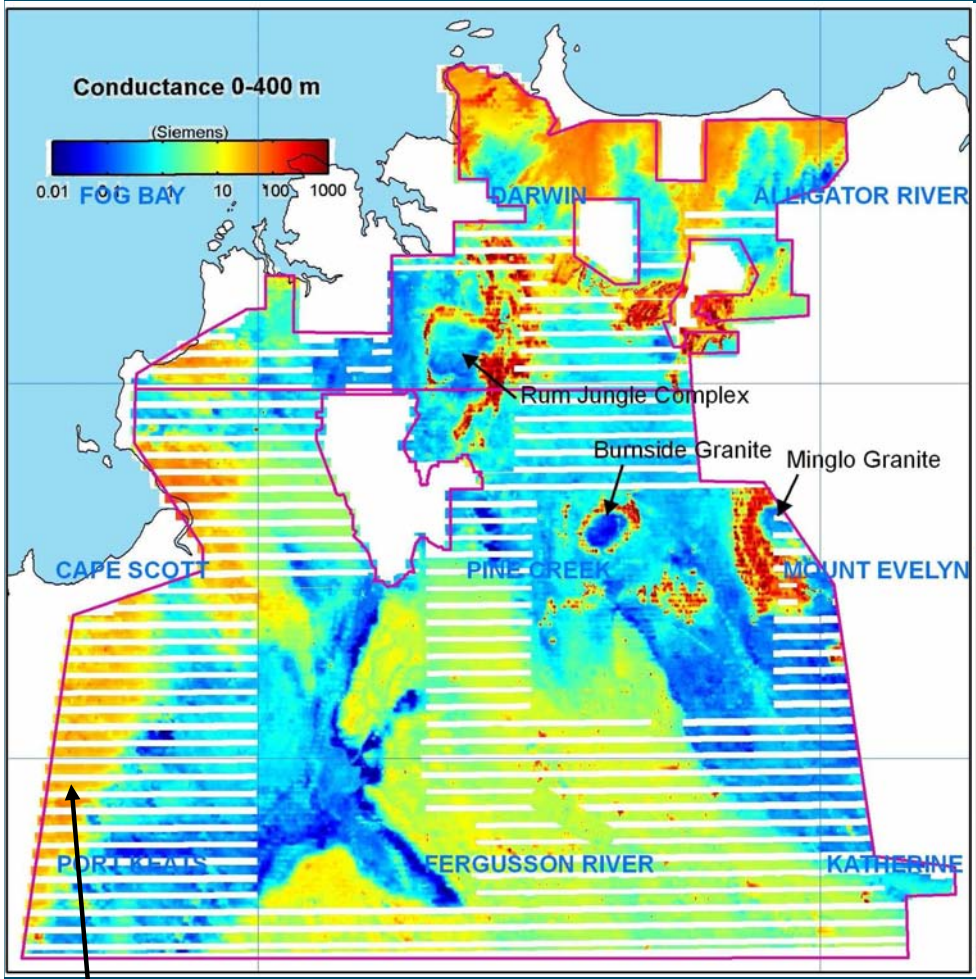
- Faulted and folded
- Multiple deformations
- AEM assists mapping of faults and folds, particularly under regolith cover

Mapping faults and folds using AEM

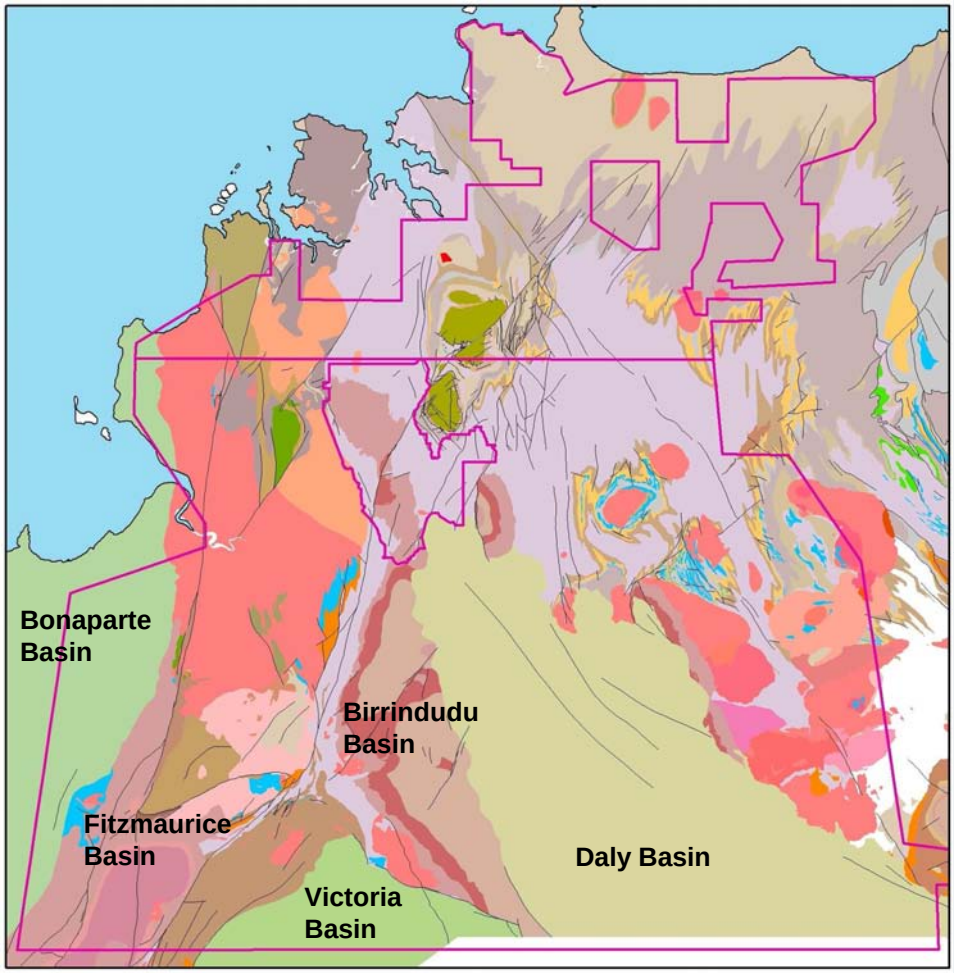




Conductance image



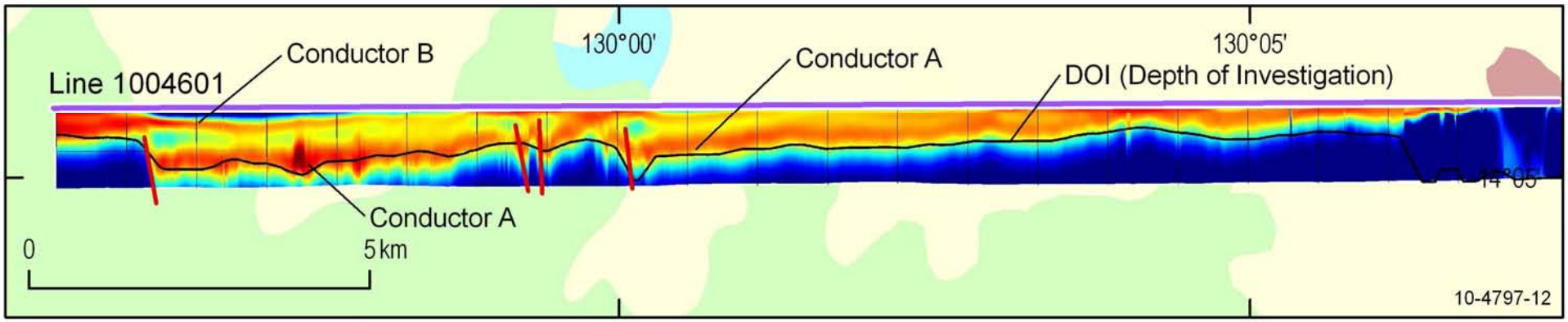
Solid geology



Bonaparte Basin

- Composite basin, Cenozoic to Cambrian: limestone, sandstone, siltstone, basalt
- moderately conductive

Bonaparte Basin



Cenozoic

Alluvium

Undivided

Permian

Kulshill Formation

Proterozoic

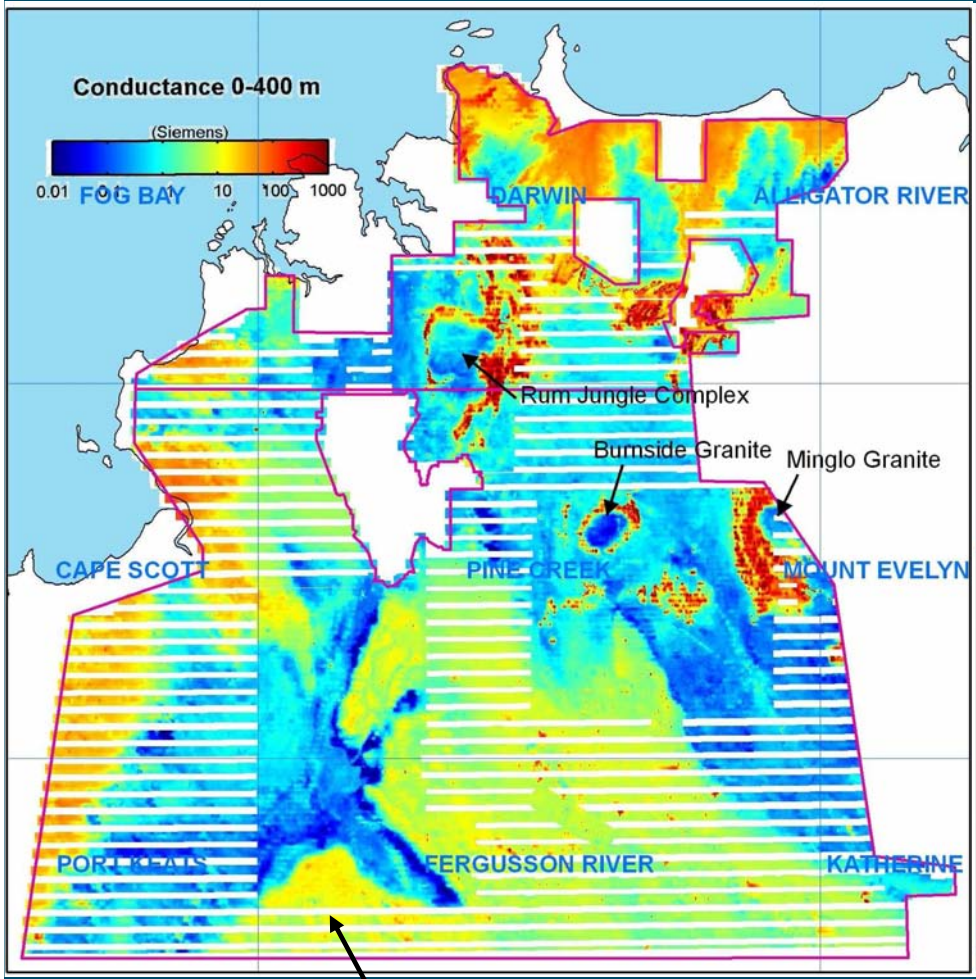
Fitzmaurice Group

Fault

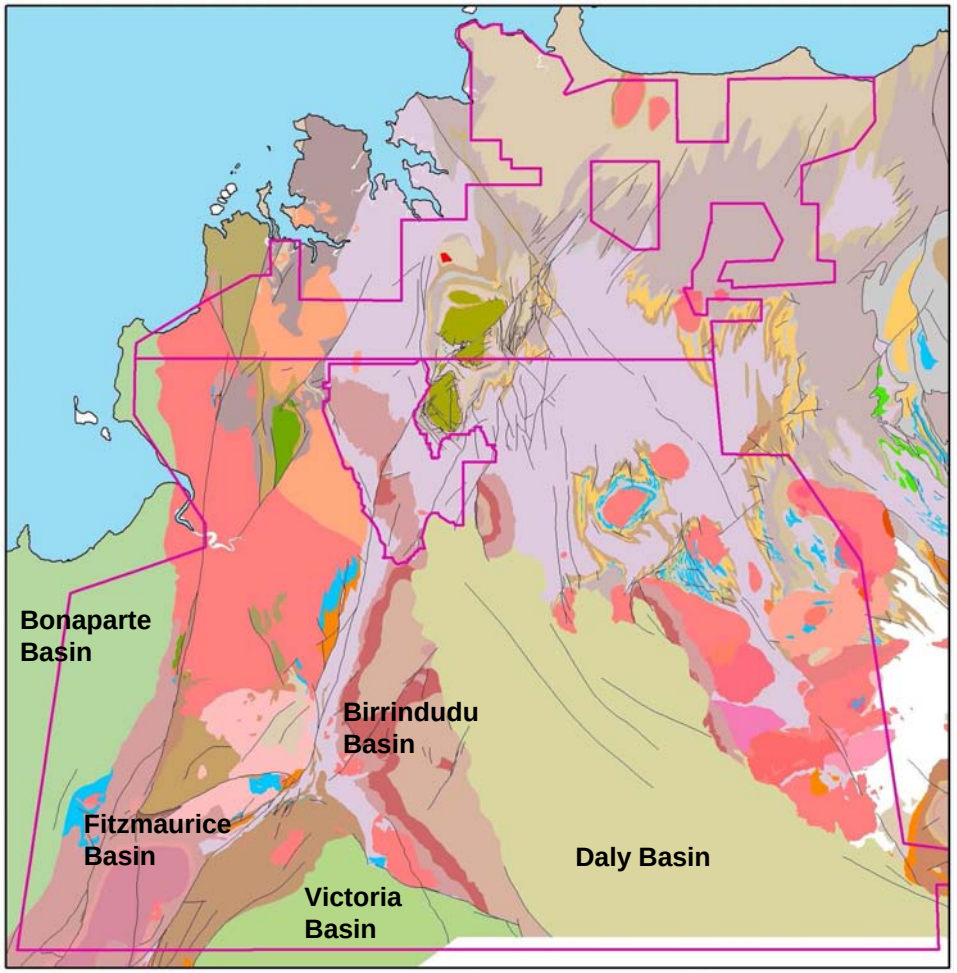
AEM survey line

- Conductors in Permian sediments

Conductance image



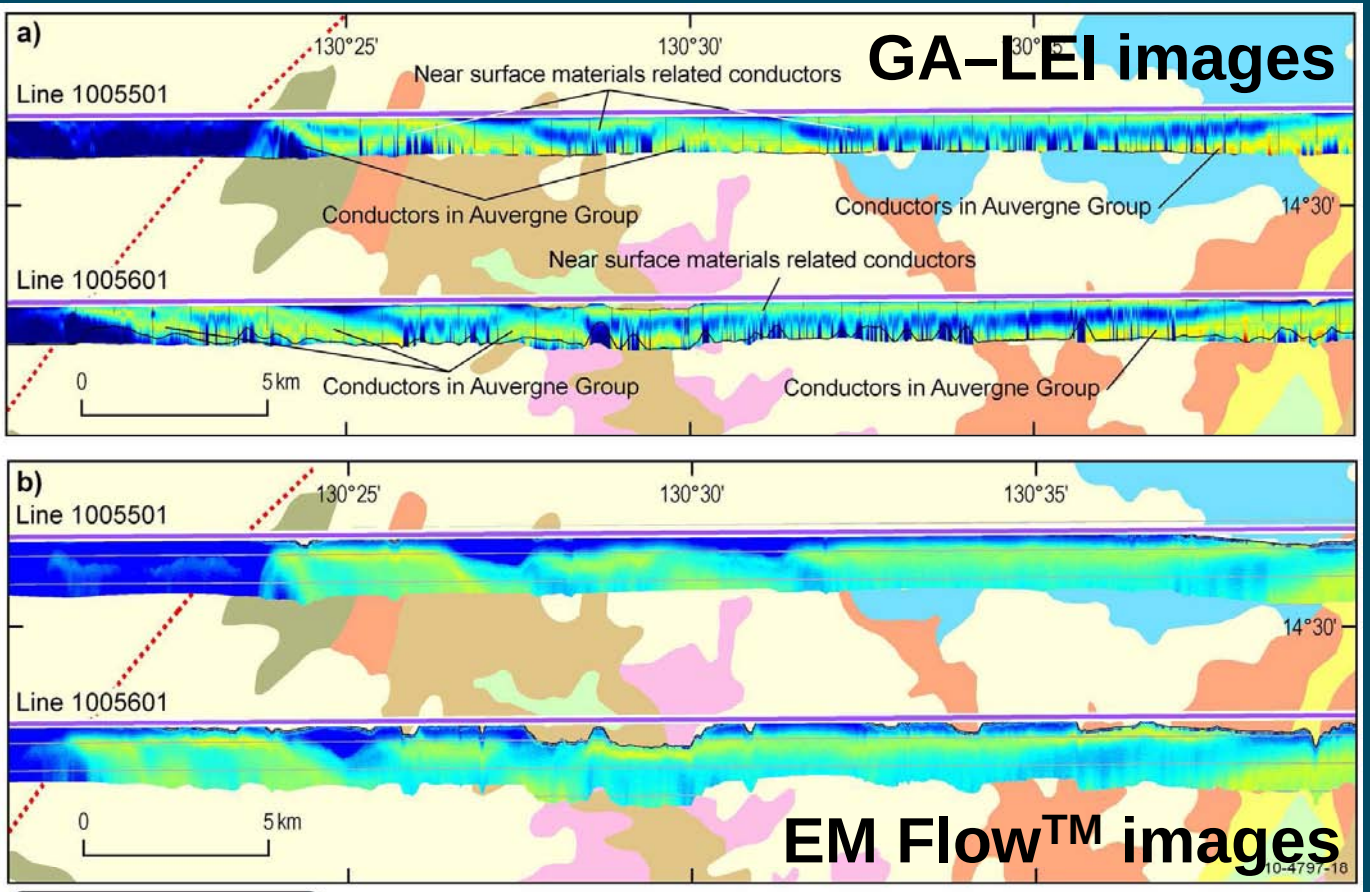
Solid geology



Victoria Basin

- Neoproterozoic (~ 950m): dolostone, sandstone, limestone & shale
- moderately conductive

Victoria Basin



- GA-LEI images show more details
- Several conductors in Auvergne Group

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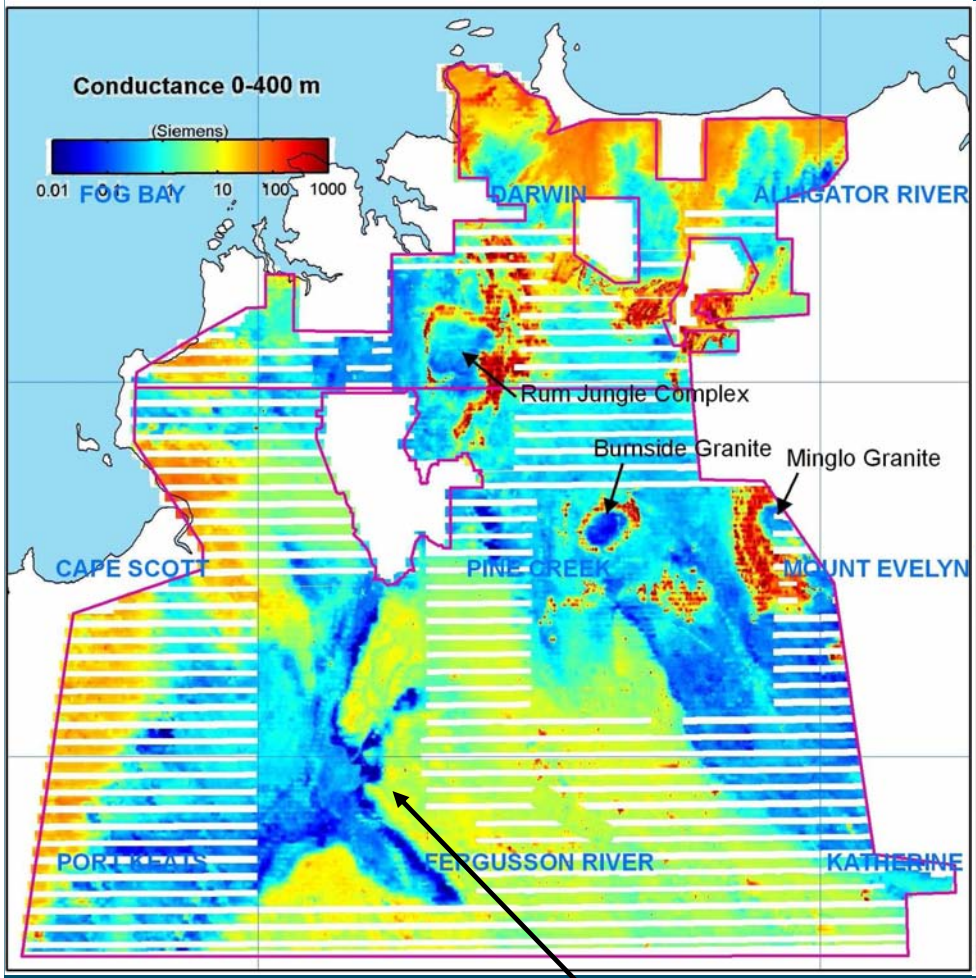
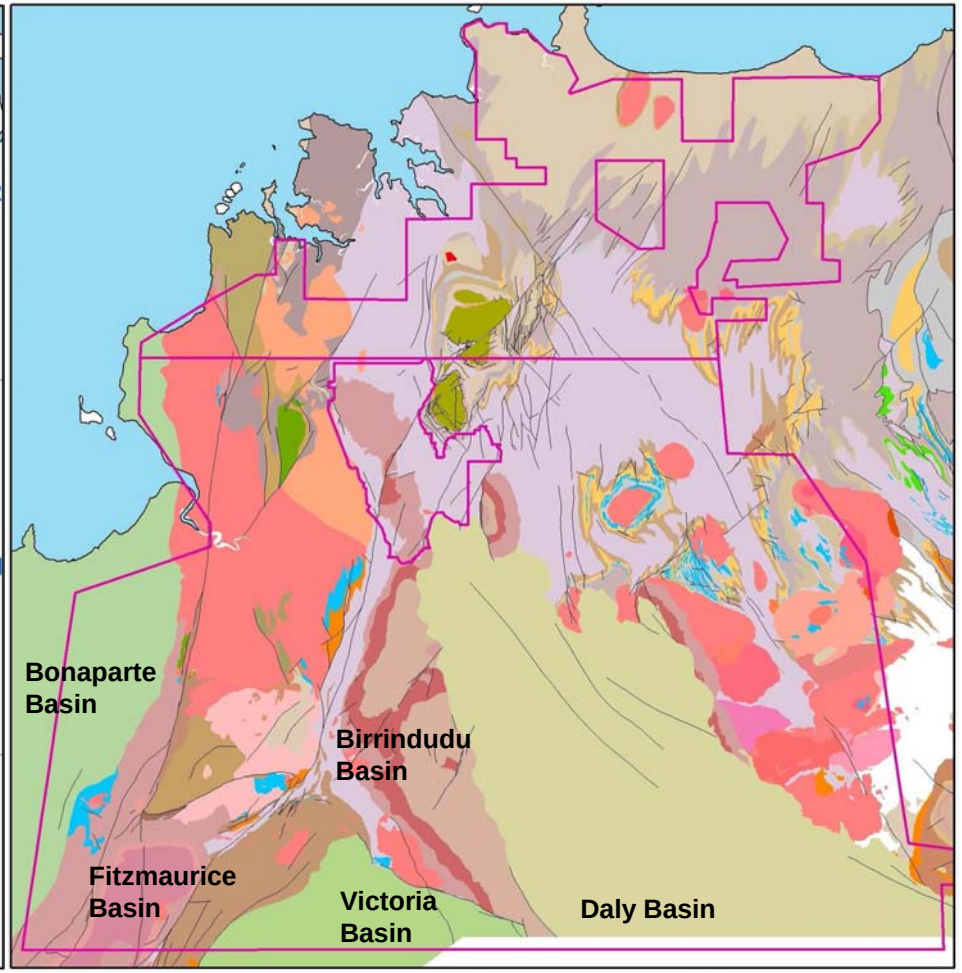
Conductance image



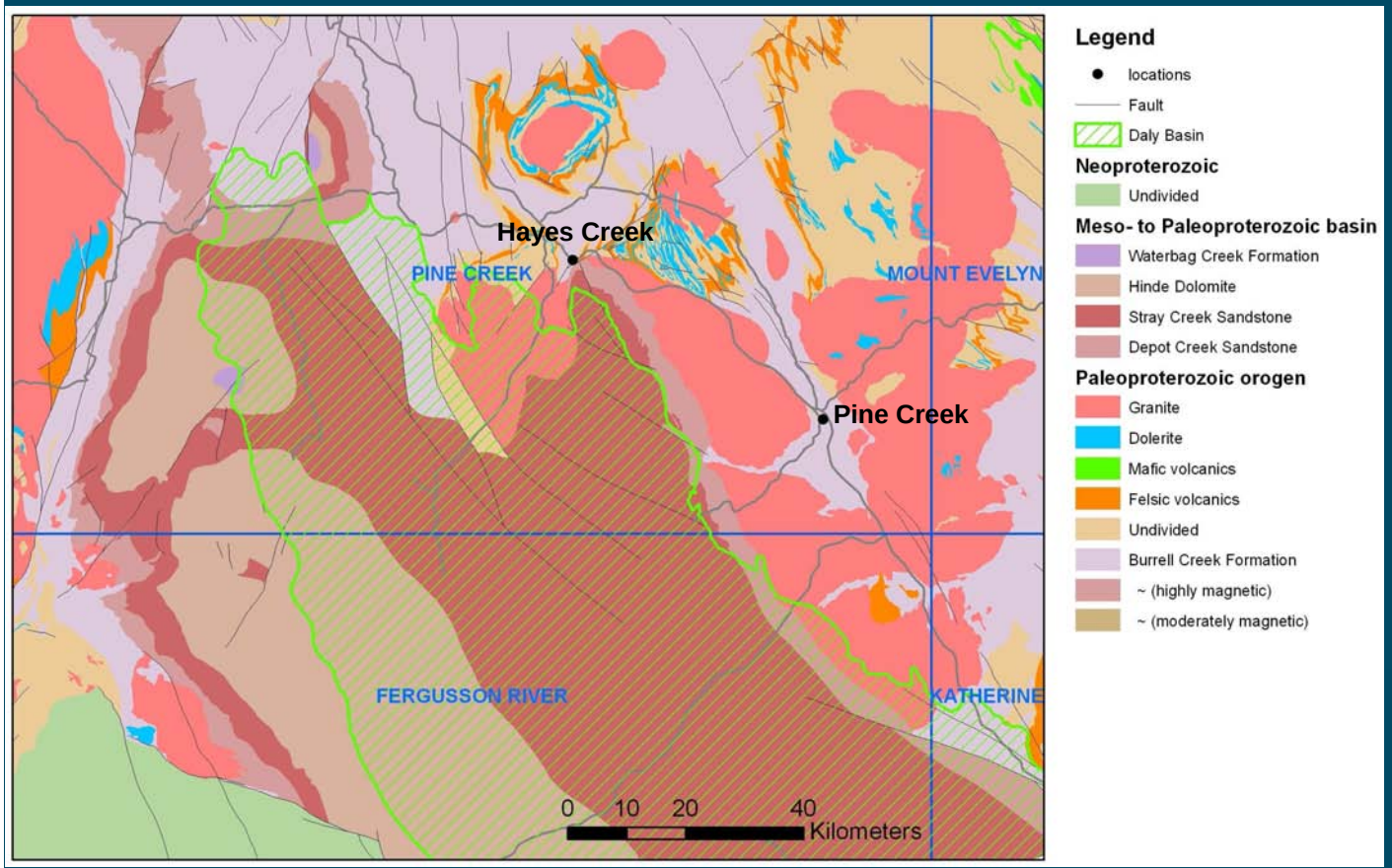
Solid geology



Birrindudu Basin

- Unconformably overlying Pine Creek Orogen & overlain by Daly Basin
  - Depot Creek Sst, Stray Creek Sst, Hinde Dolomite, Waterbag Creek Fm
- Overall moderately conductive, largely due to Stray Creek Sst

Birrindudu Basin



More work

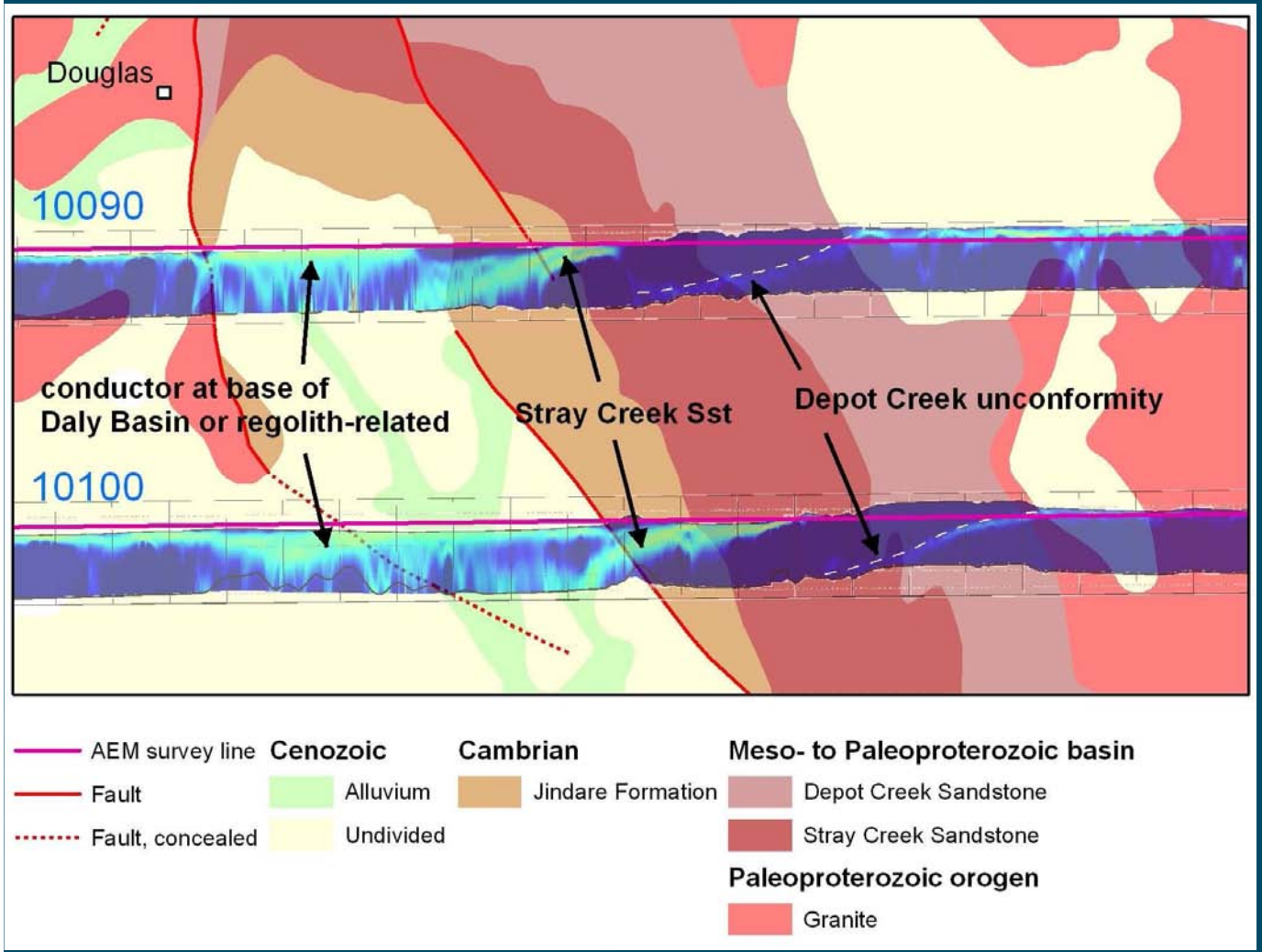
- 3D model of Daly Basin & underlying Proterozoic
- Improve solid basement geology: details from drill holes
- Evaluate presence of Archean

- Covered by Daly Basin: Depot Creek Sst <100 m at margins, but >500 m in central part of the Basin
- Unconformity of Depot Creek Sandstone over Pine Creek Orogen


Depot Creek
Sandstone

Depot Creek Sandstone

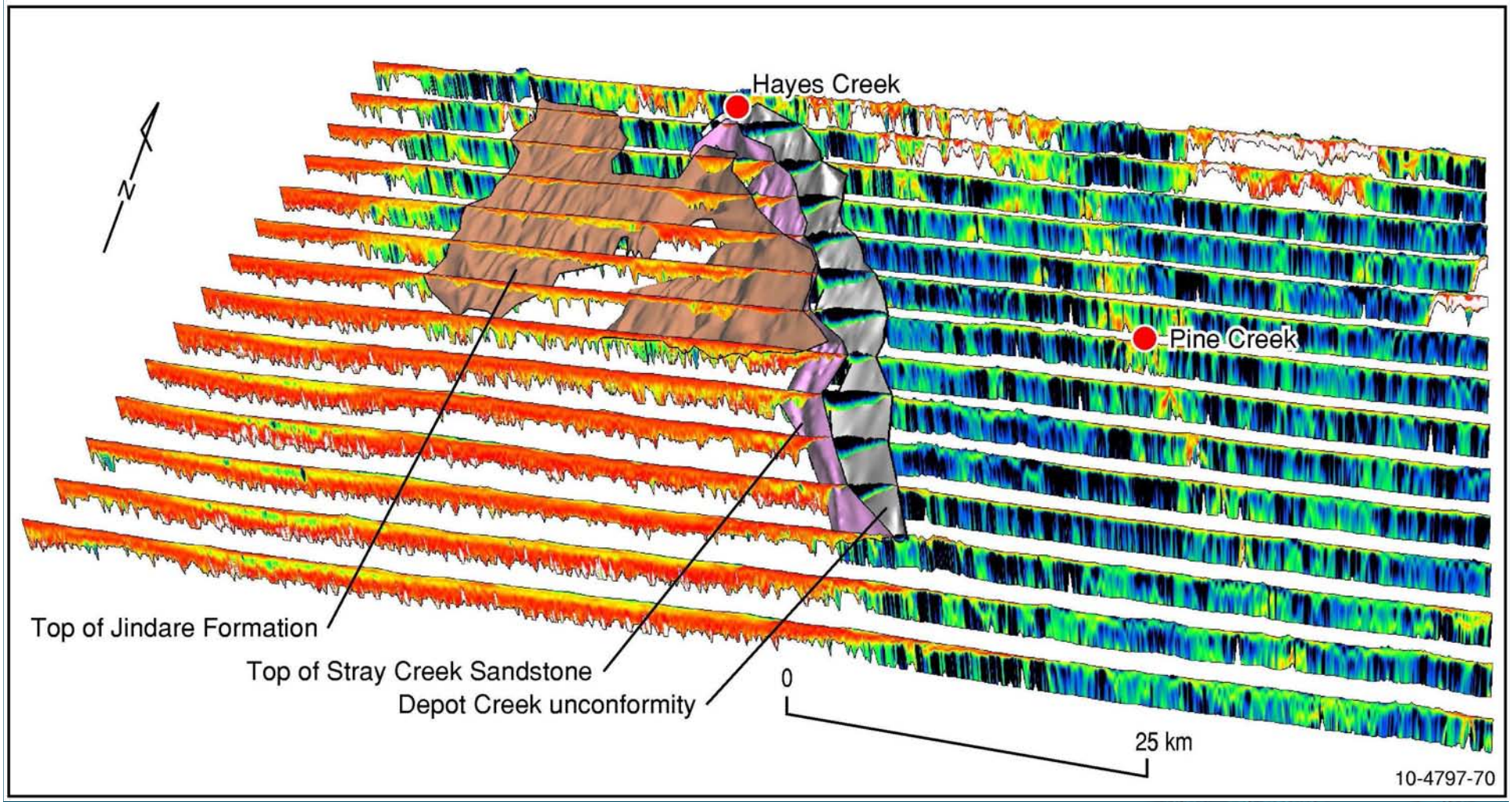
‘Depot Creek unconformity’



Mapped in AEM:

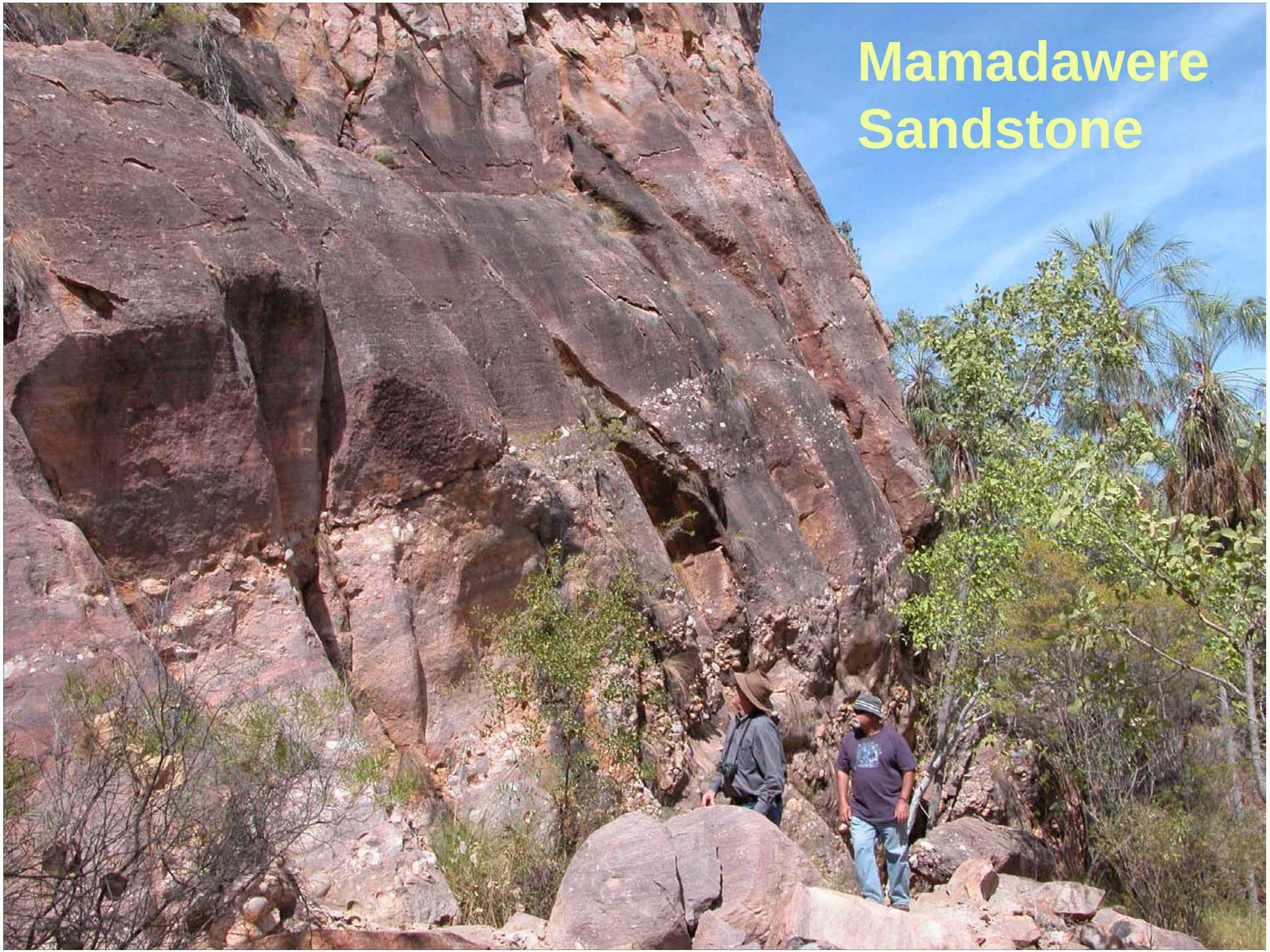
- Base of Daly Basin or regolith-related
- Conductor in Stray Creek Sandstone
- Depot Creek unconformity

Hayes Creek – Pine Creek area

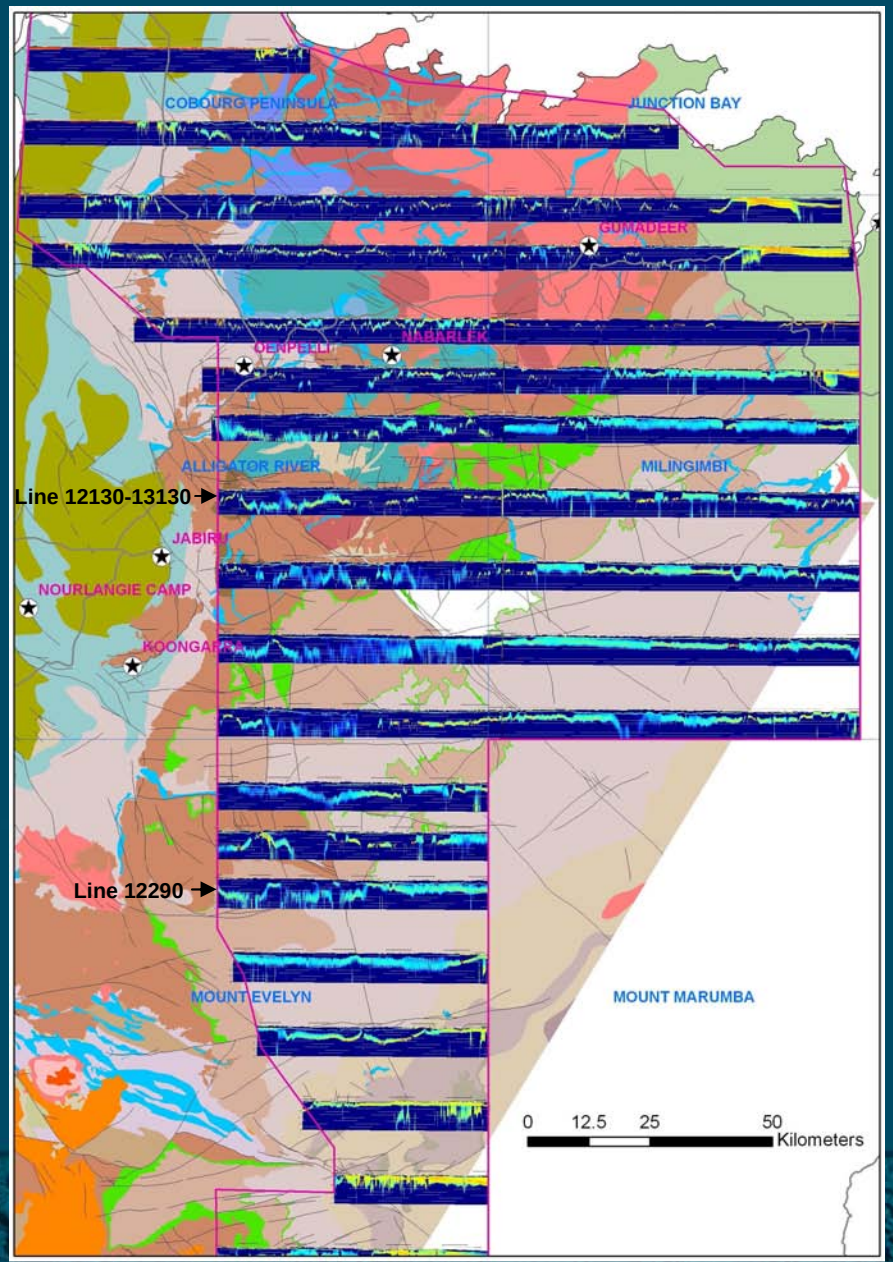


AEM in 3D: • Mapped 3 horizons in 3D


Katherine River

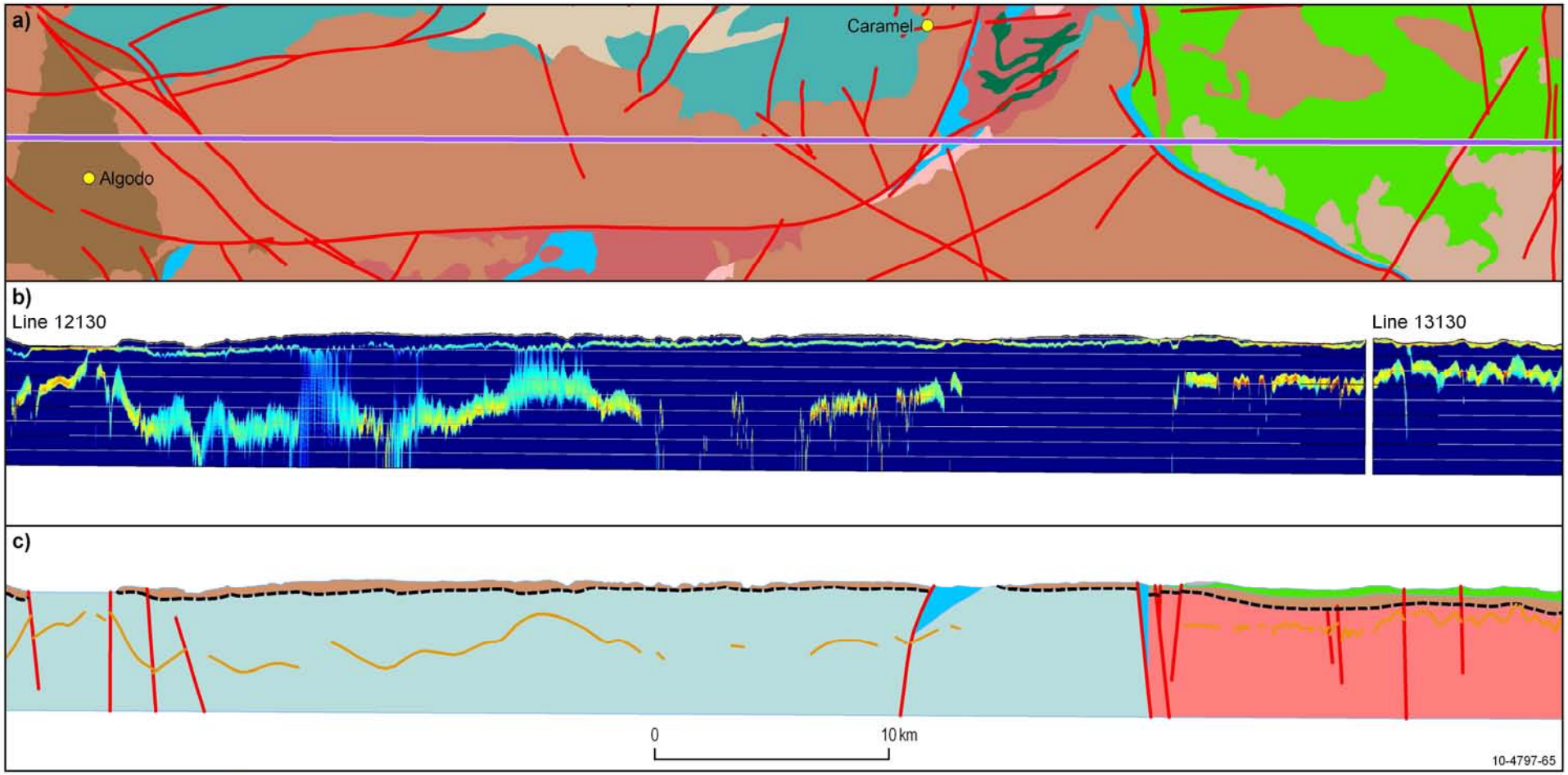

Mamadawere
Sandstone

Kombolgie AEM survey by VTEM™

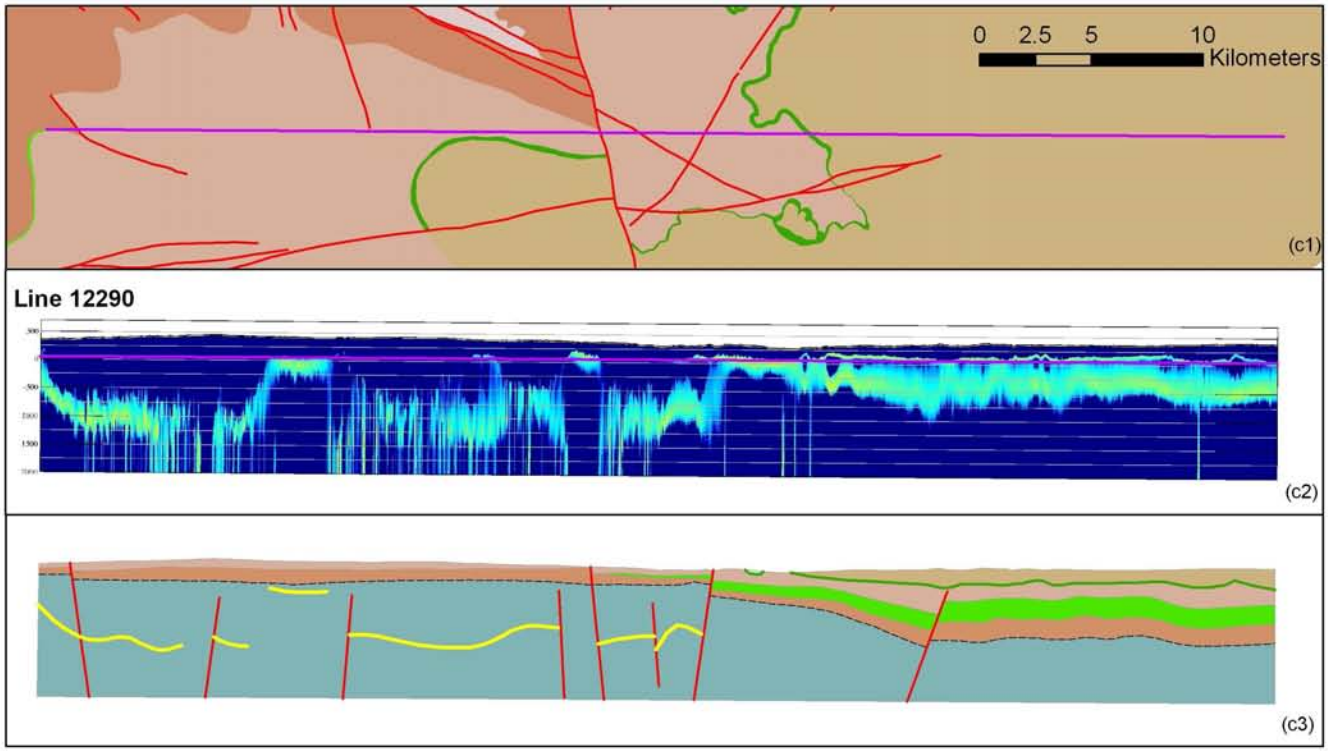


- Extremely resistive
- Kombolgie unconformity
- Nungbalgarri Volcanics & Gilruth Volcanic Member
- Conductors in the pre-Kombolgie basement
  - to a depth of down to 2 km
  - **world first!**
- Some faults mapped

Kombolgie survey – cross section interpretation



Kombolgie survey – cross section interpretation



Legend

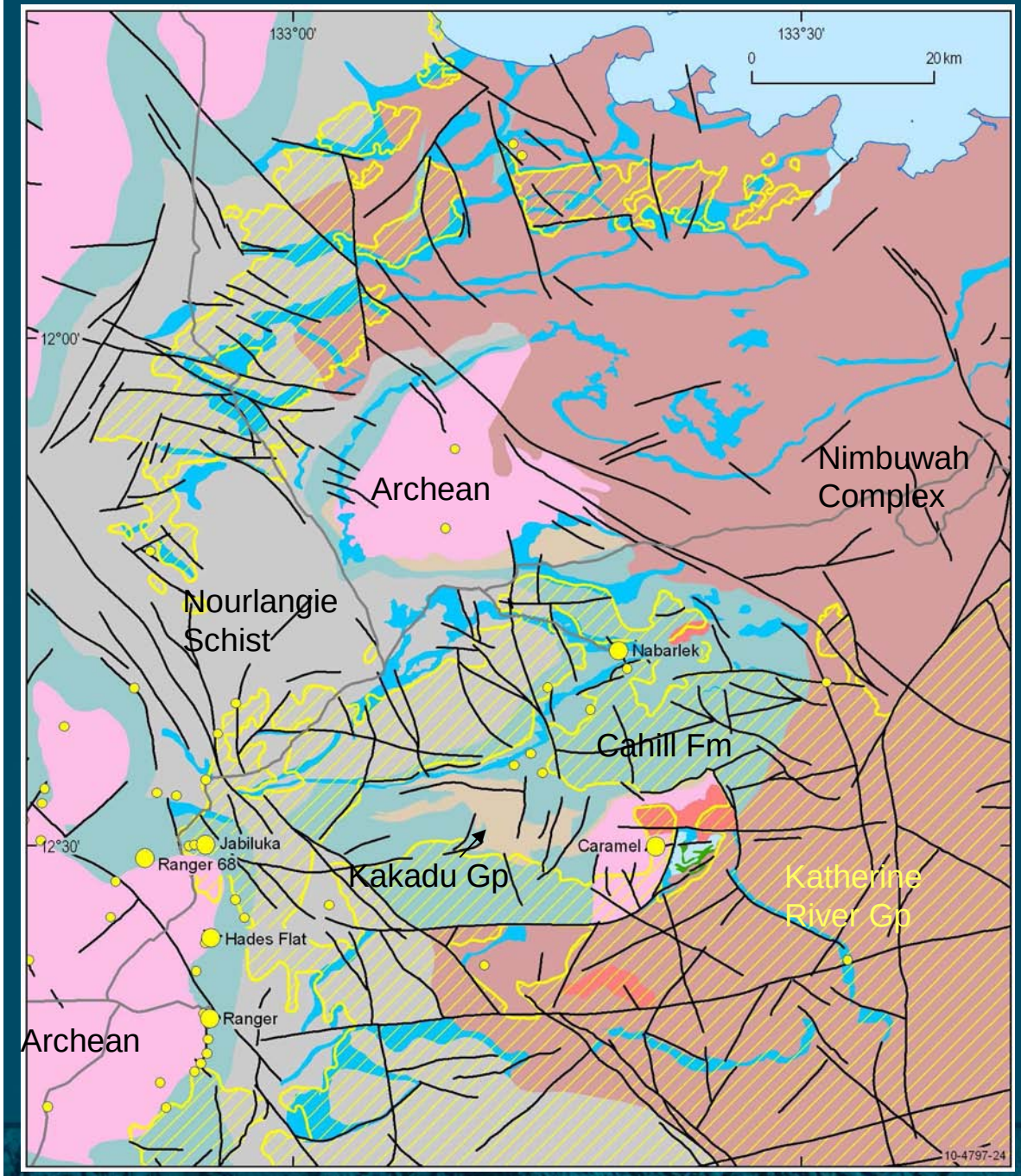
- AEM survey line
- Fault
- conductors in pre-Kombolgie basement
- unconformity

Mesoproterozoic to Archean

- Marlgowa Sandstone
- Gilruth Volcanic Member
- Gumarrirnbang Sandstone
- Nungbalgarri Volcanics
- Mamadawerre Sandstone
- pre-Kombolgie basement, including Archean
- Nourlangie Schist

c1: solid geology with AEM survey lines
(solid geology after NTGS (2005))
c2: EM Flow section (Line 12290)
c3: interpreted cross-section

- McArthur Basin deepens to east and south in AEM survey area



Pre-Kombolgie solid geology

- Katherine River Group
- Oenpelli Dolerite & amphibolite
- Nourlangie Schist
- Cahill Formation
- Kadadu Group
- Archean

AEM

- Kombolgie unconformity
- Stratigraphic units & conductors (reductors)
- Faults

Conclusions

- AEM useful for mapping shallow crust
  - help define depth and character of regolith
- Mapping unconformities
- Mapping conductive reductants below unconformities
  - Detection to a depth of down to 2 km
- Mapping structures (faults and folds)
- Implications for exploring uranium mineral systems

Future work

- Mapping key components of unconformity – related uranium mineral systems:
  - Distribution of conductive reductants in pre-Kombolgie or pre-Depot Creek basements – from AEM and drill hole data
  - Palaeotopography and 3D modelling: to determine fluid flow directions during diagenesis and inversion of basins
  - Map faults that could have seen fluids

Acknowledgement

- The contributions of Ross Brodie, Richard Lane and Professor James Macnae (RMIT) who greatly assisted with the Kombolgie dataset.
- Northern Territory Geological Survey
- Natural Resources, Environment, The Arts and Sport (NRETAS)
- National Water Commission
- The Northern Land Council, for granting access to traditional lands.
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- Subscription companies Crossland Uranium Mines Ltd., Hapsburg Exploration Pty. Ltd., the National Water Commission, Rio Tinto Exploration Pty. Ltd., Rum Jungle Uranium (now Rum Jungle Resources Ltd), Southern Uranium Ltd., Thundelarra Exploration and United Uranium Ltd., Uranex NL for their support of the AEM project by funding additional lines, supplying historical data and providing geological support.


Thank you