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Major Mineral Systems in the PCO: Implications of AEM Data for Uranium Mineral Systems

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with assistance from GA-AEM Team and NTGS geologists

Major Mineral Systems in PCO

- World-class (U, Au); Significant deposits (Sn, Ta, W, Fe, Cu, Ni, Co, Pb-Zn and magnesite)
- Past Reviews:
  - Deposits on the PINE CREEK sheet, Ahmad et al., 1993)
  - U (Lally and Bajwah, 2006; Ahmad et al., 2006)
  - Au (Ahmad et al., 2009)
  - Rum Jungle Mineral Field (Ahmad et al., 2006)
  - Sn-Ta pegmatite (Frater, 2005)
- Main objective of the review
  - assist interpretation of AEM data
  - comment on mineral potential of uranium systems

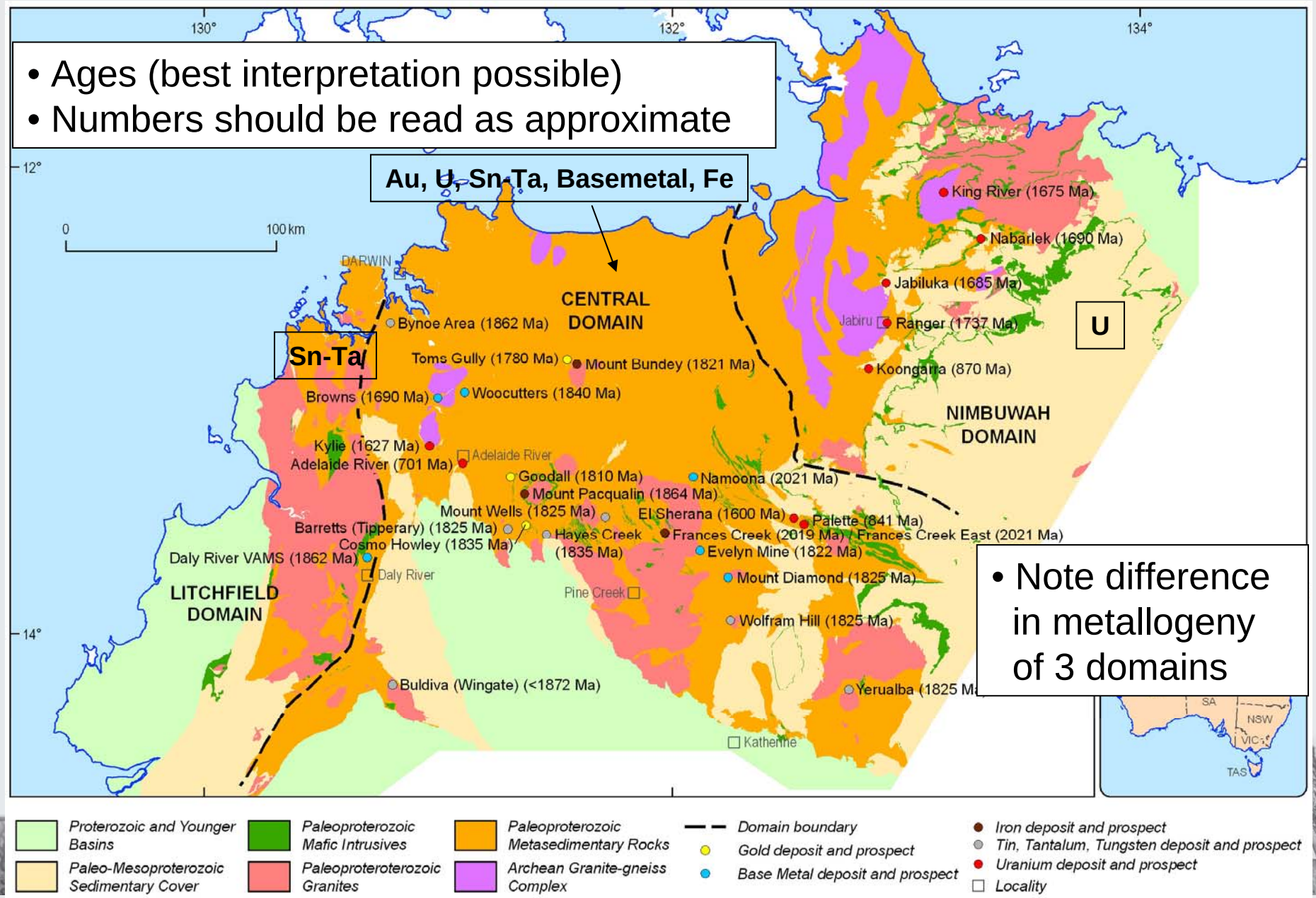
Review of Major Mineral Systems in PCO

- Compile ages of mineral deposits
- Timing of mineralisation and of other events
- Construct time-space-event plots of 3 domains
- Define
  - critical elements and
  - mappable features U and Au systems

Outline

- Focus on uranium mineral systems
  - For other systems see GA Record
- Unconformity-related uranium systems
- Outline main features of fertile systems
- Discuss new prospective areas
- Discuss basemetal and uranium deposits in the Rum Jungle Mineral Field (RJMF)

Age of Major Deposits

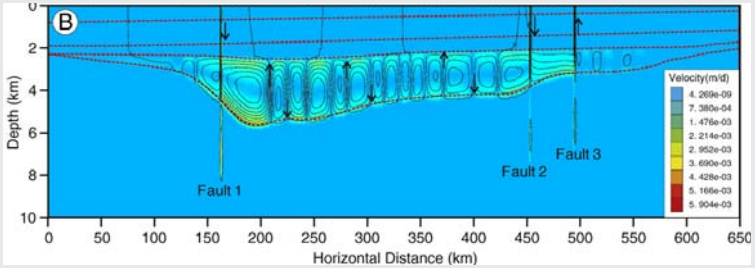


Six Groups of Major Mineral Systems

- Basin-related
  - Volcanic-associated (Pb-Zn, Cu, Fe)
  - Associated with diagenetic fluids (U, Pb-Zn, Cu, magnesite)
- Deformation and/metamorphism-related
  - Lode Au
  - Base metal sulphide (Woodcutters)
- Felsic magmatism-related
  - Vein, pegmatite, greisen, skarn (Sn, Ta, W, Pb-Zn, Cu, Fe, REEs?)
- Regolith-related
  - Iron
- Hybrid
  - Lode Au, Iron, magnesite

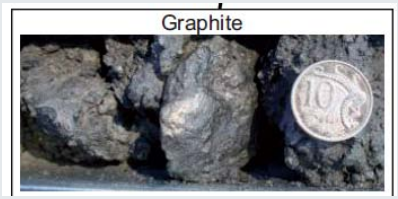
Unconformity-Related Uranium (what we know)

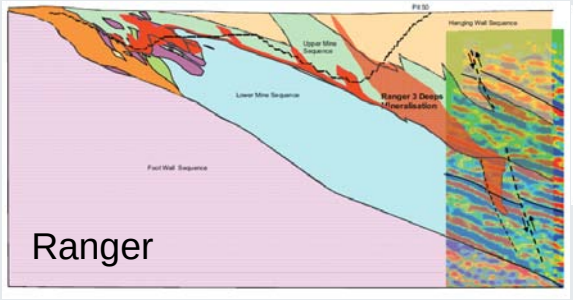
- Diagenetic fluids
- Uranium sourced from
  - metasediments and/or
  - ‘paleoregolith’

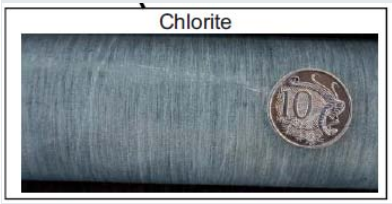


Reactive transport modelling, Thelon Basin

- Fluid flow along
  - sandstone aquifers
  - unconformity
  - faults

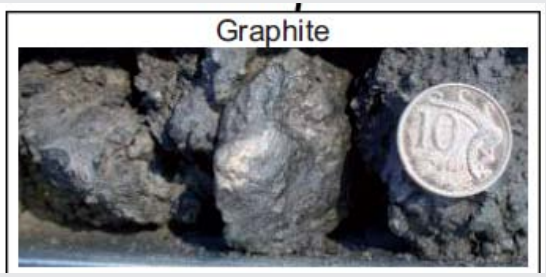


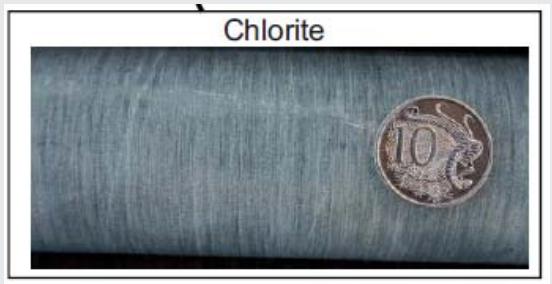


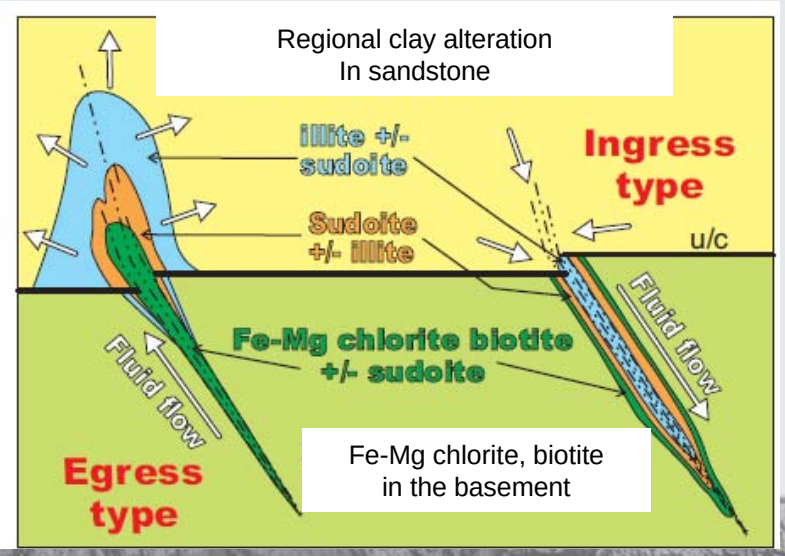


- Deposition in
  - structures, breccia zone
  - reduced rocks (graphite?, chlorite)

Graphite As Reductant (?)







Graphite not effective

- at < 250°C reaction slow
- graphite not always present (e.g. Nabarlek)

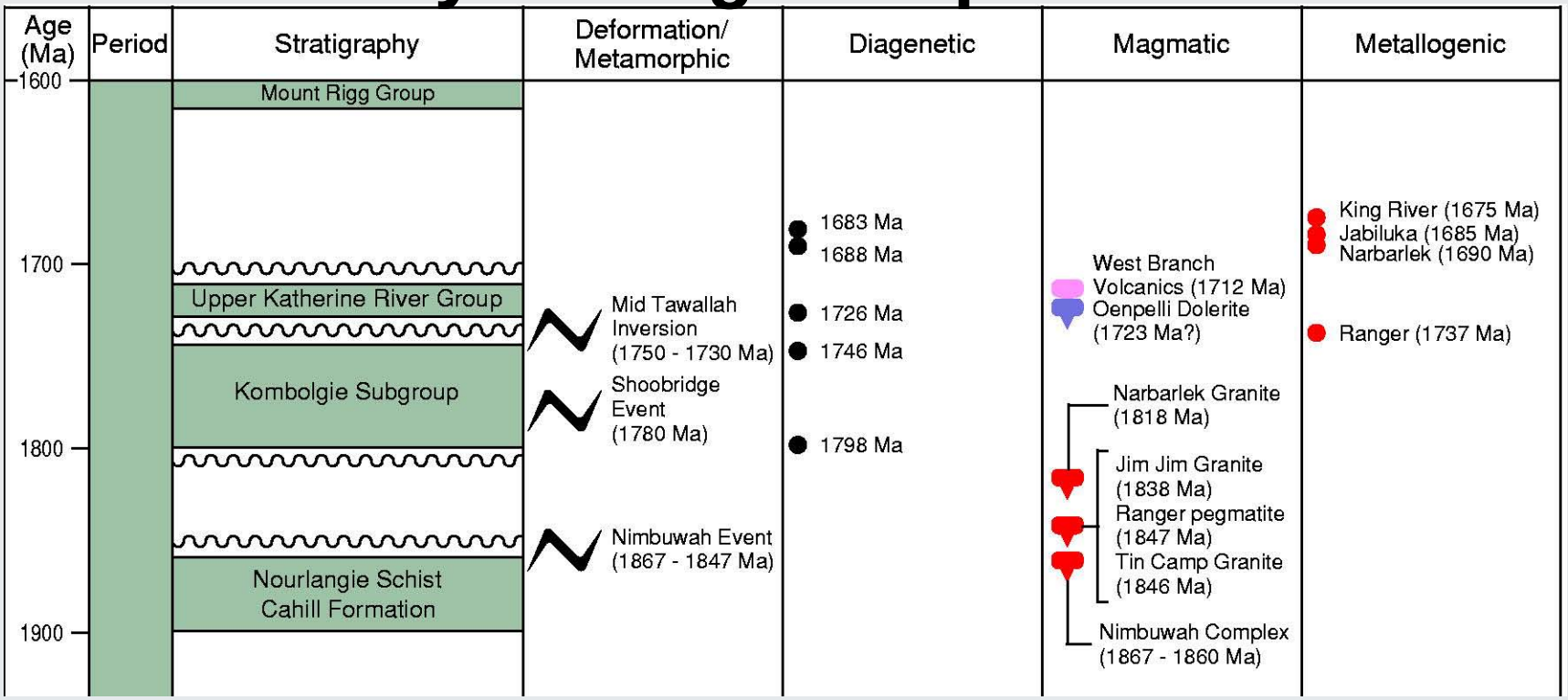
Fe-Chlorite (best alternative)

- replacement of Fe-chlorite by illite/clay
- releases Fe
- reduces fluid to deposit U
- oxidises to magnetite/hematite
- note alteration zones in deposits:
  - outer chlorite
  - inner illite, clay, hematite

Graphite still important

- can form reductants (hydrogenation)
- map ore-localising structures

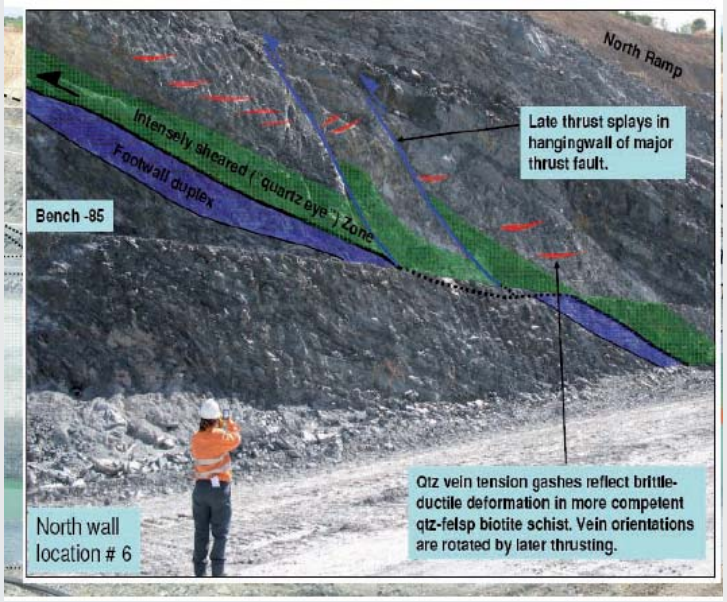
Why Timing is Important



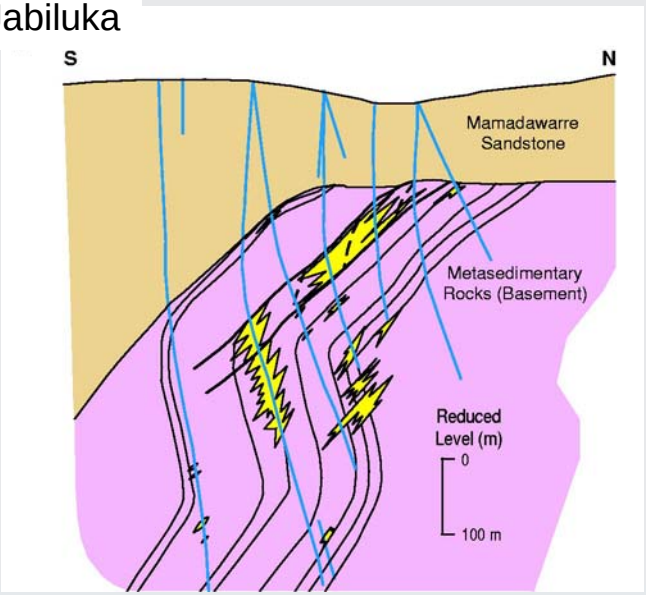
- Deposition of Katherine River Group: ~1810 Ma to ~1710 Ma
- Diagenesis: 1798 Ma; 1746 Ma; 1726 Ma; 1690 Ma to 1680 Ma
- Mid-Tawallah Inversion (1750 Ma to 1730 Ma)
- Uranium deposits: Ranger at ~1740 Ma; Jabiluka, Nabarlek (1690 Ma to 1680 Ma)
- Two Uranium-episodes and two inversion-events
- Two Uranium-episodes and two magmatic events (Mafic at ~1720 Ma; Felsic at ~1710 Ma

Timing of Uranium Mineralisation

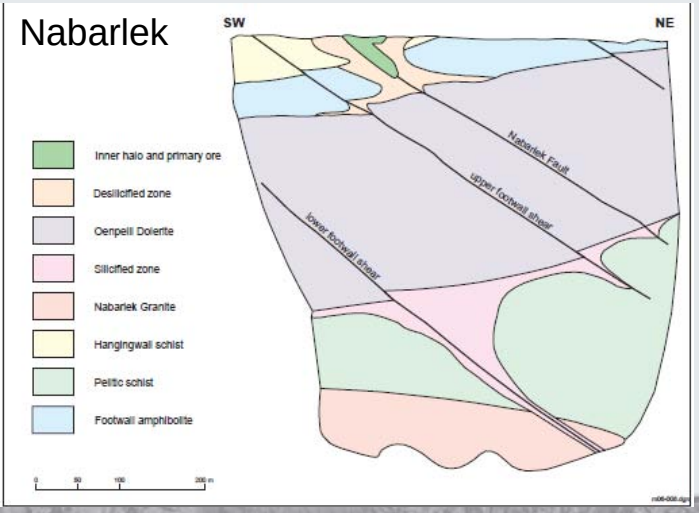
Ranger



Jabiluka

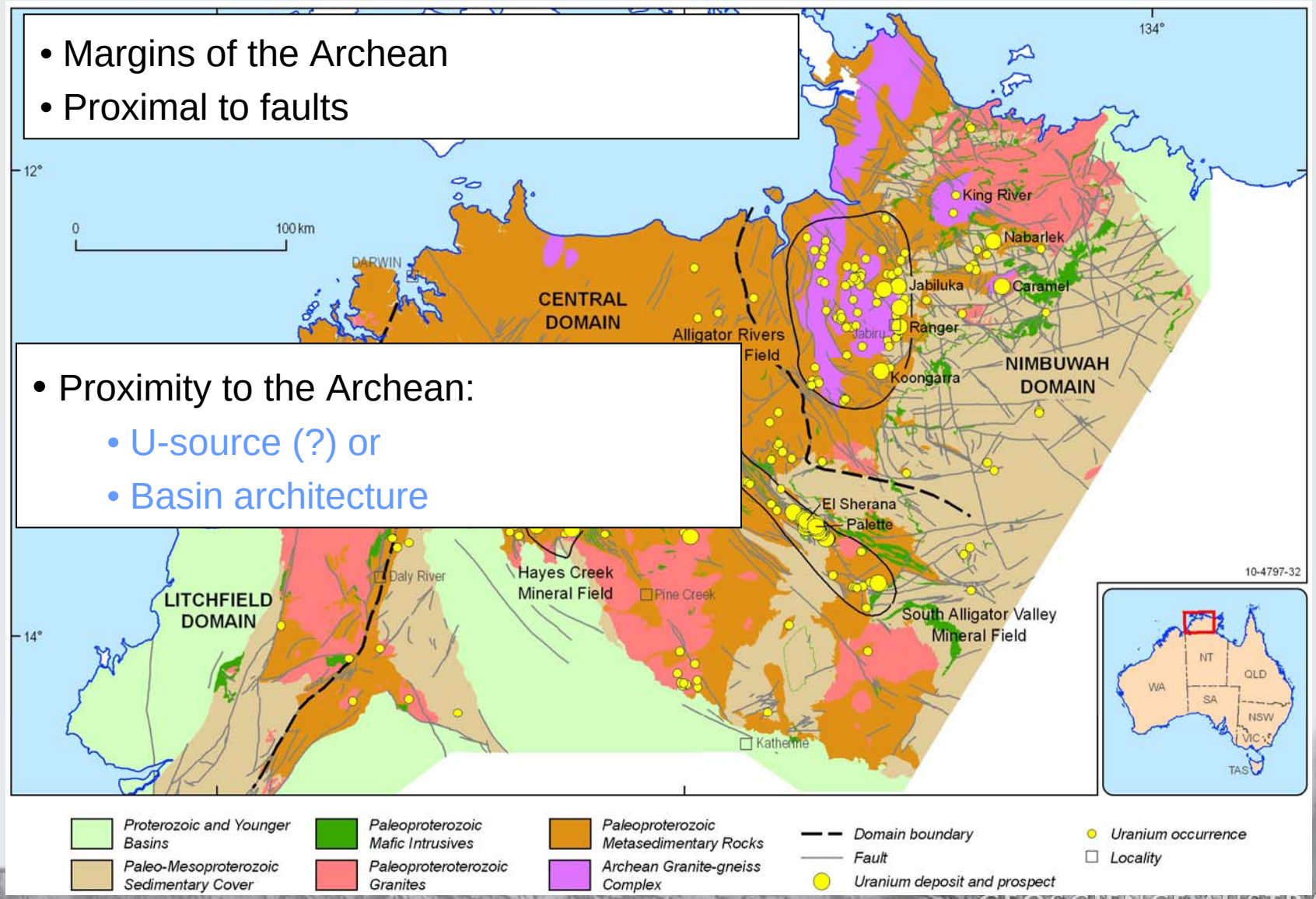


Nabarlek

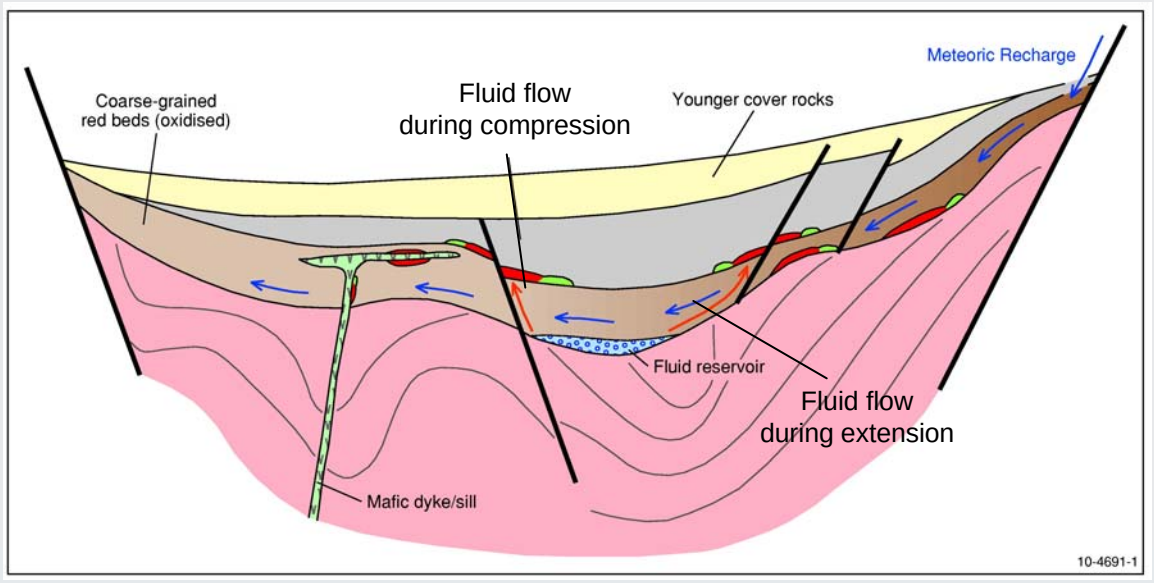


- Main phase of mineralisation during compression
- Two events important:
  - extension (sedimentation, diagenesis)
  - compression (expulsion of fluids from the basin)

Uranium Deposits and Prospects

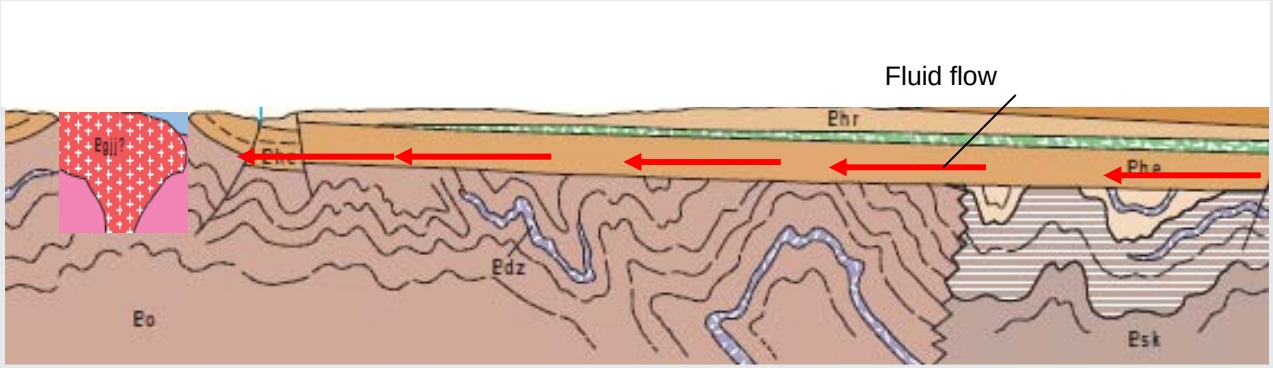


Two-Fluid-Flow Events



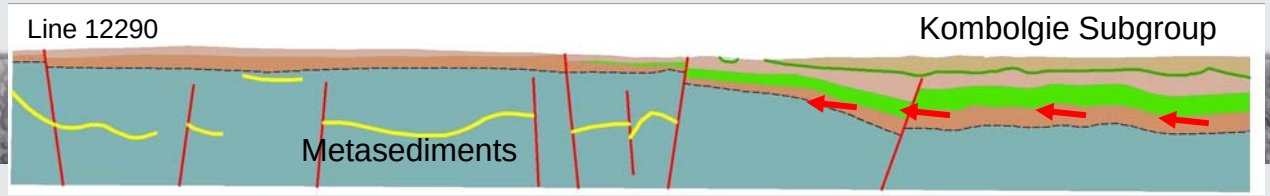
Extension

- Sedimentation
- Diagenesis
- Fluid reservoir



Basin inversion

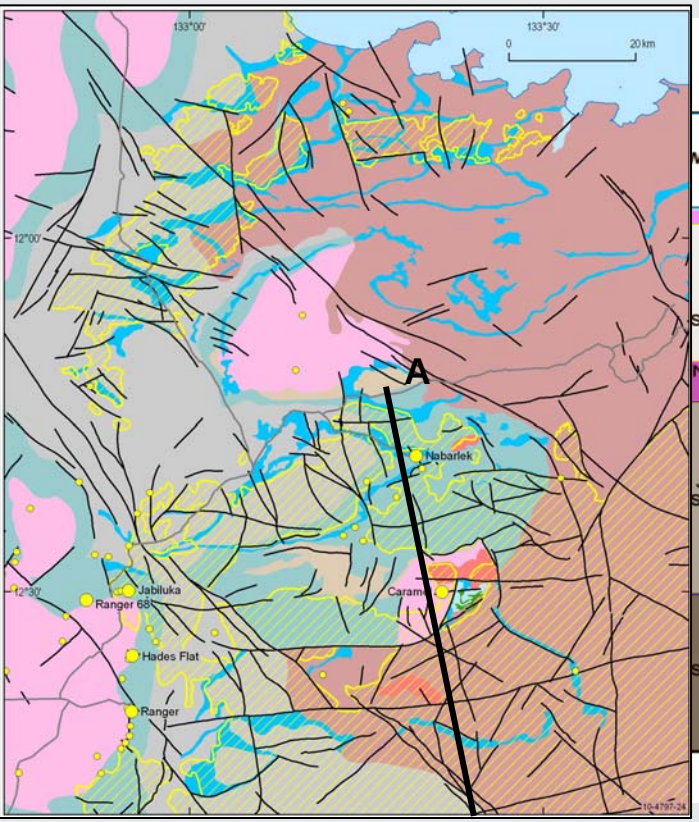
- Compression
- Expulsion of fluids from the basin

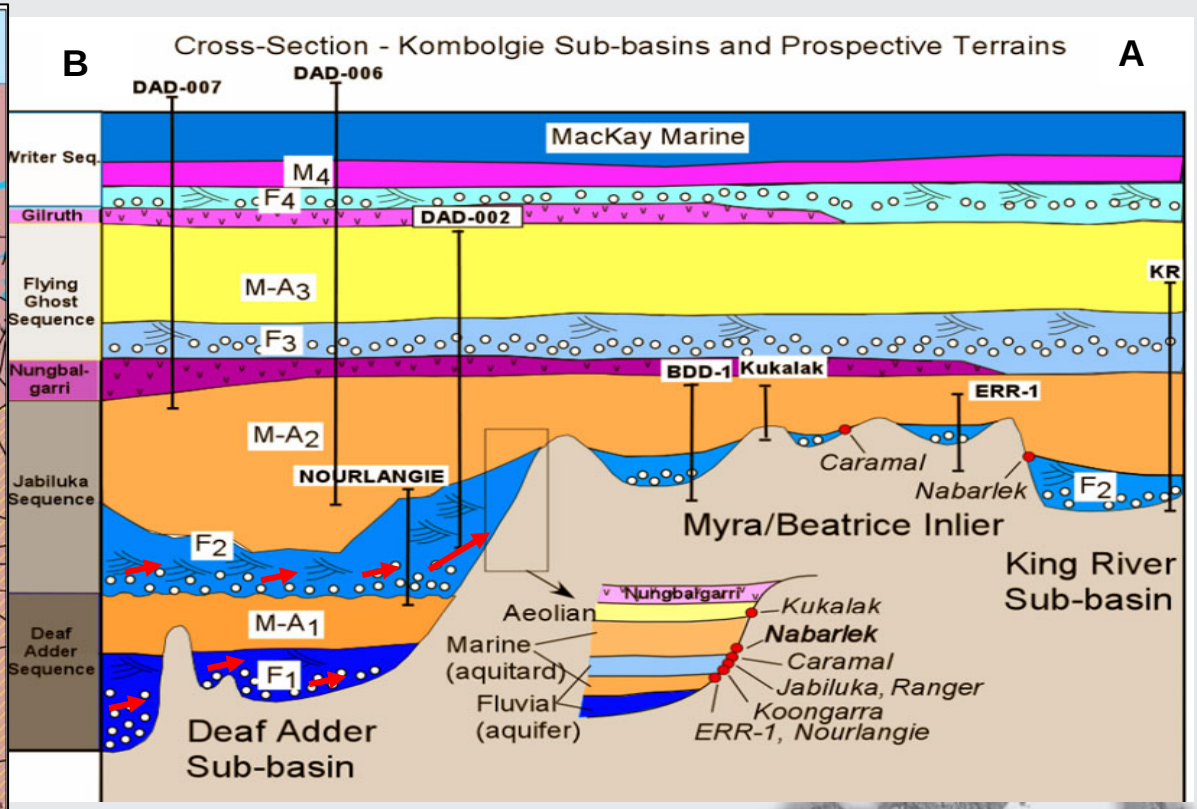


Diagenetic Model of Unconformity-Related U

(Kyser and Cunney, 2008)

Pre-Kombolgie solid geology
Nabarlek – Caramal area



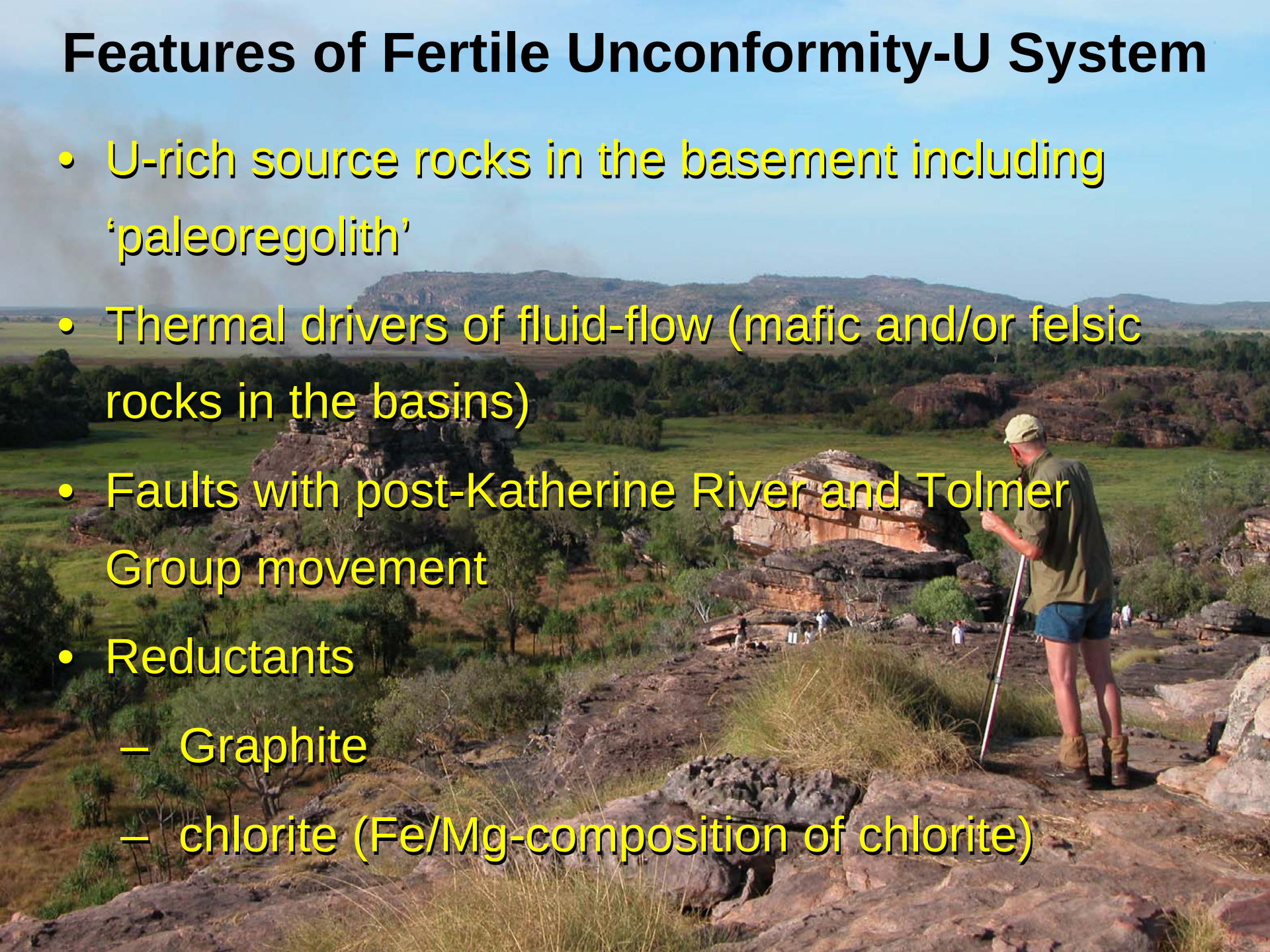


Features of Fertile Unconformity-U System

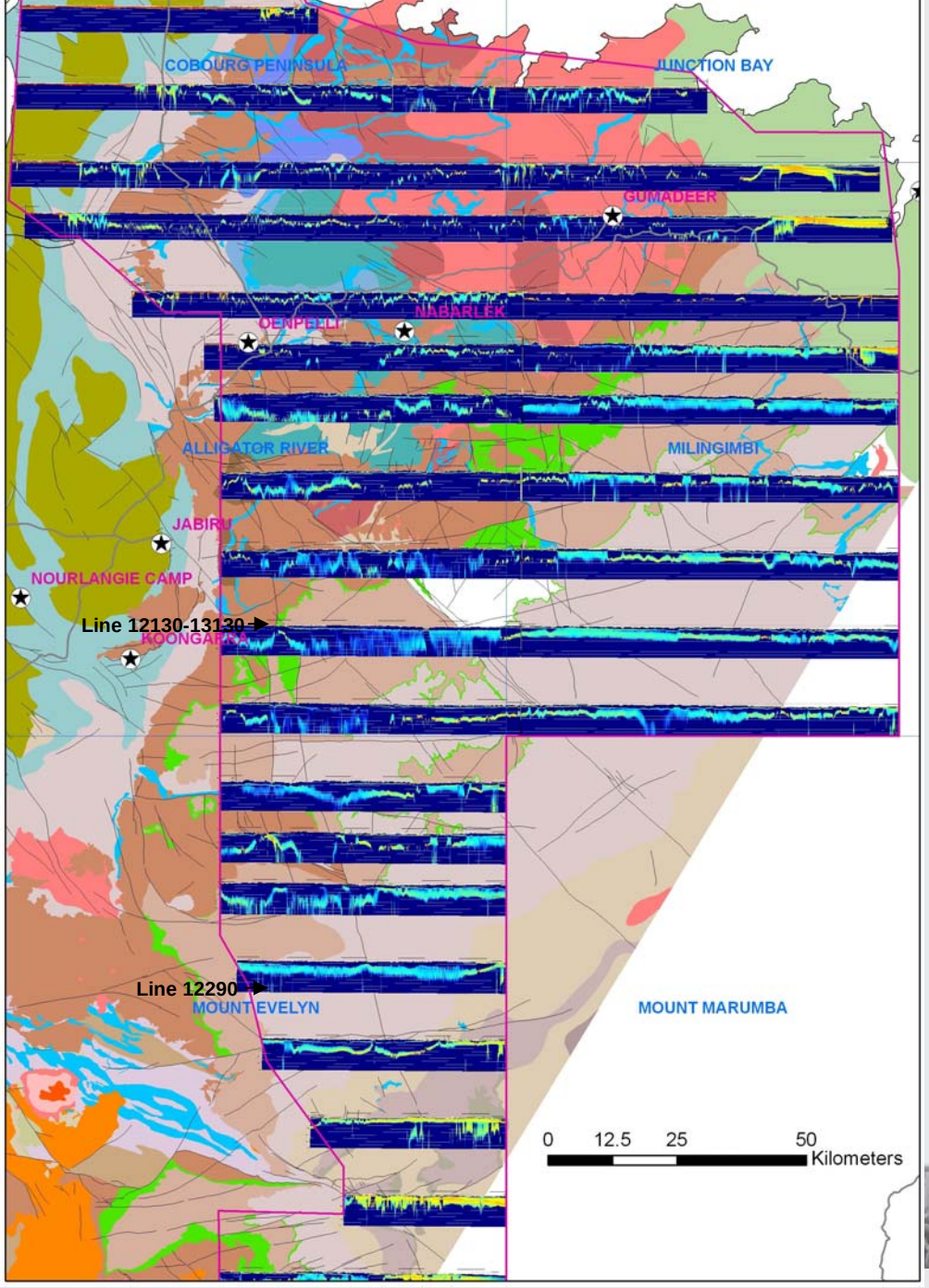
Architecture of McArthur (Katherine River Group) and Birrindudu basins (Tolmer Group)

- Unconformity (depth and basement rocks)
- Pre-erosional extent of the basin
- Sub-basins
- Sediment thickness (>4 to 5 kms important)
- Structures and history of movement
- Diagenetic history (very important)

Features of Fertile Unconformity-U System



- U-rich source rocks in the basement including ‘paleoregolith’
- Thermal drivers of fluid-flow (mafic and/or felsic rocks in the basins)
- Faults with post-Katherine River and Tolmer Group movement
- Reductants
  - Graphite
  - chlorite (Fe/Mg-composition of chlorite)



Kombolgie AEM Survey by VTEM™

Create a 3D model of basin architecture using:

- AEM sections
- Drill hole data

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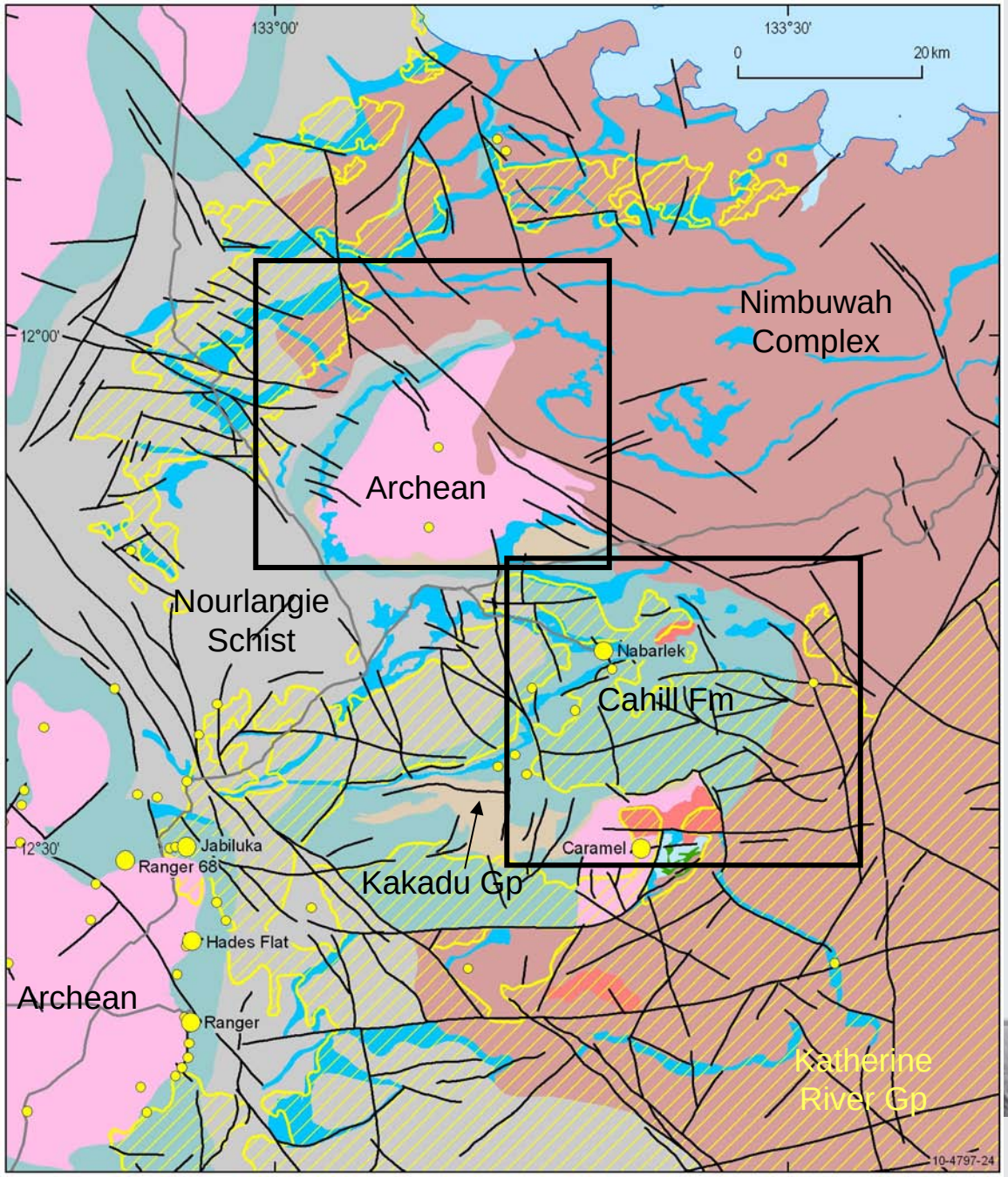
Prospective Areas in the Nimbuwah Domain



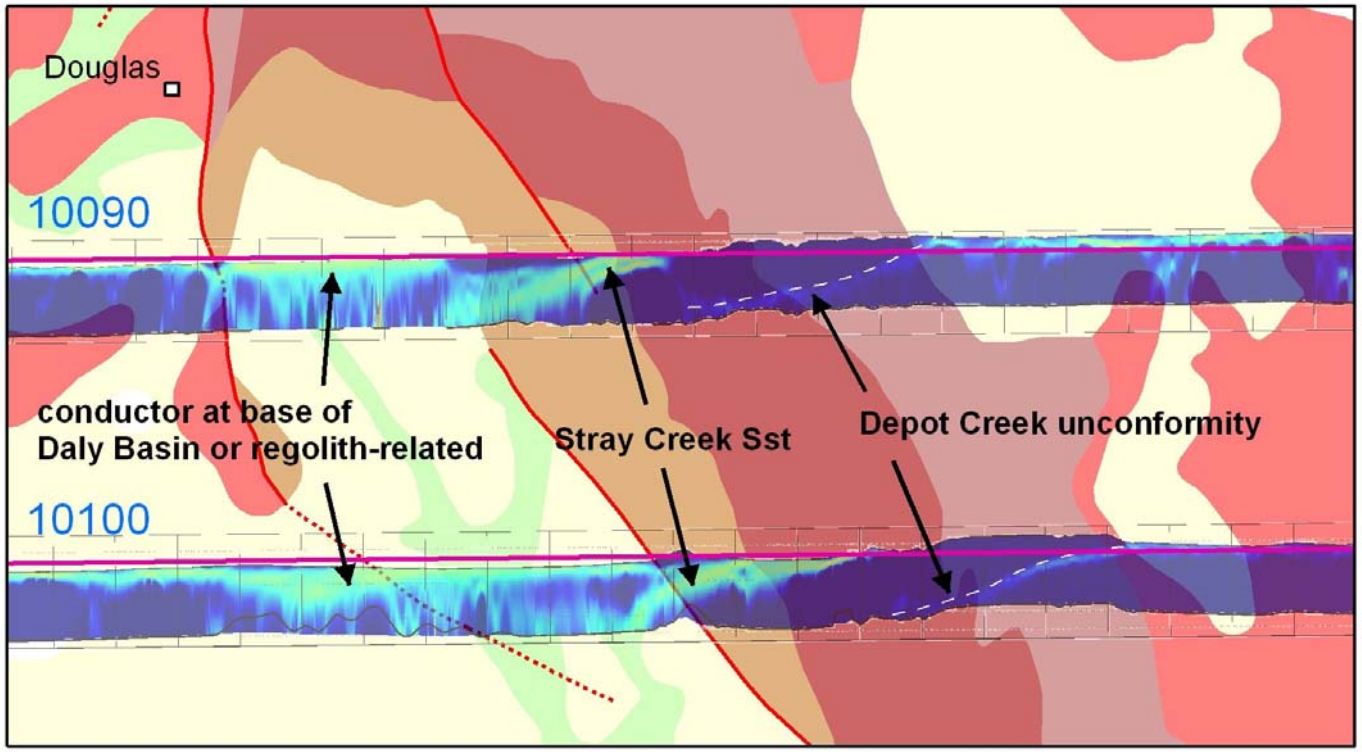
Unconformity-related U

- Archean – topographic highs
- Diagenetic fluid flow: N- or NW-trending (Kyser & Cuney 2008)
- Reductants (e.g., Cahill Fm) at margins of paleo-highs

Prospective areas

- Marginal zones of the Archean
- Rimmed by Cahill Formation

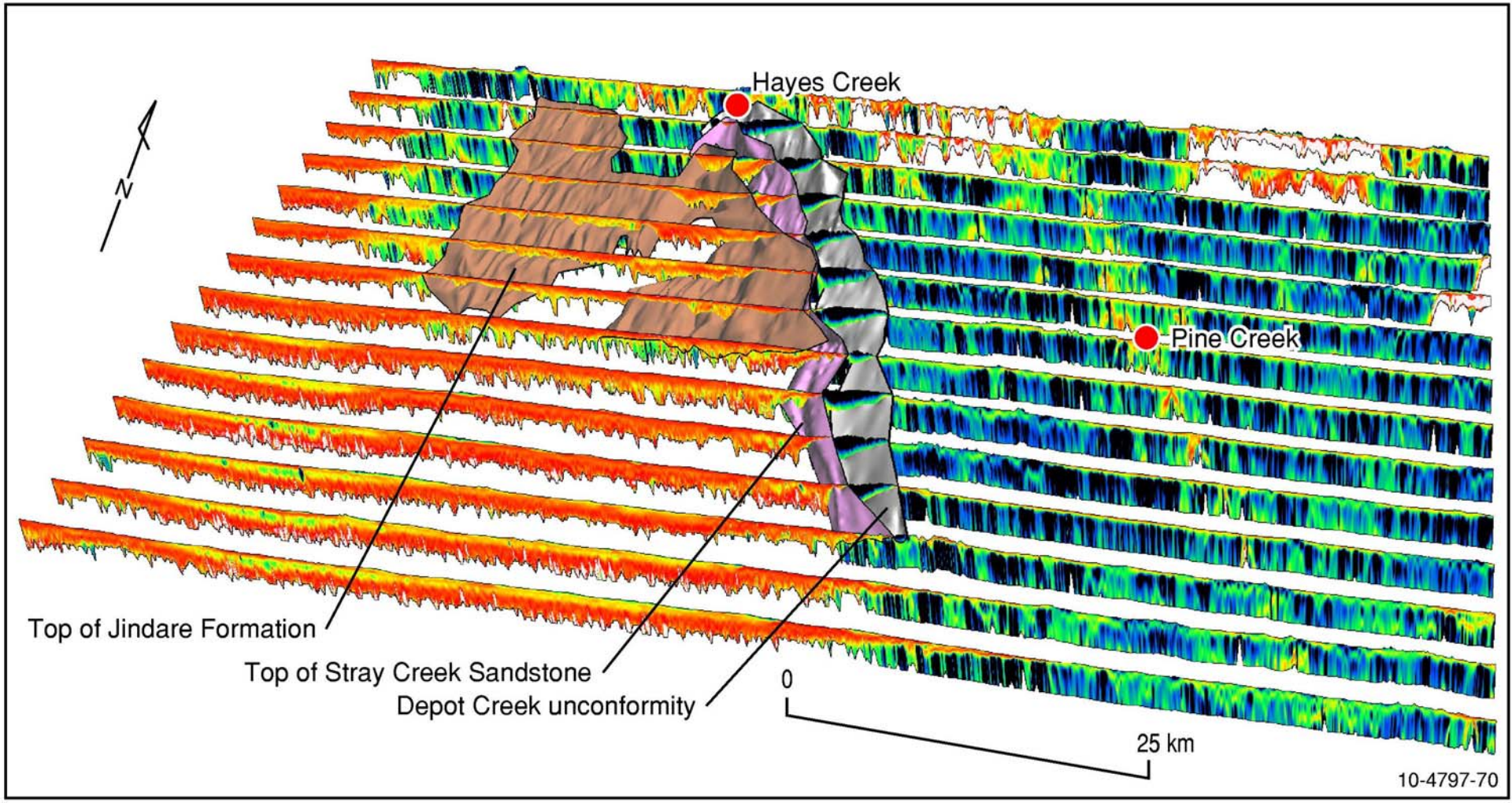
Unconformity Under Depot Creek Sandstone



Mapped in AEM:

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

Prospective Areas Near Hayes Creek – Pine Creek



AEM in 3D: • Mapped 3 horizons in 3D

Prospective areas in the Birrindudu Basin

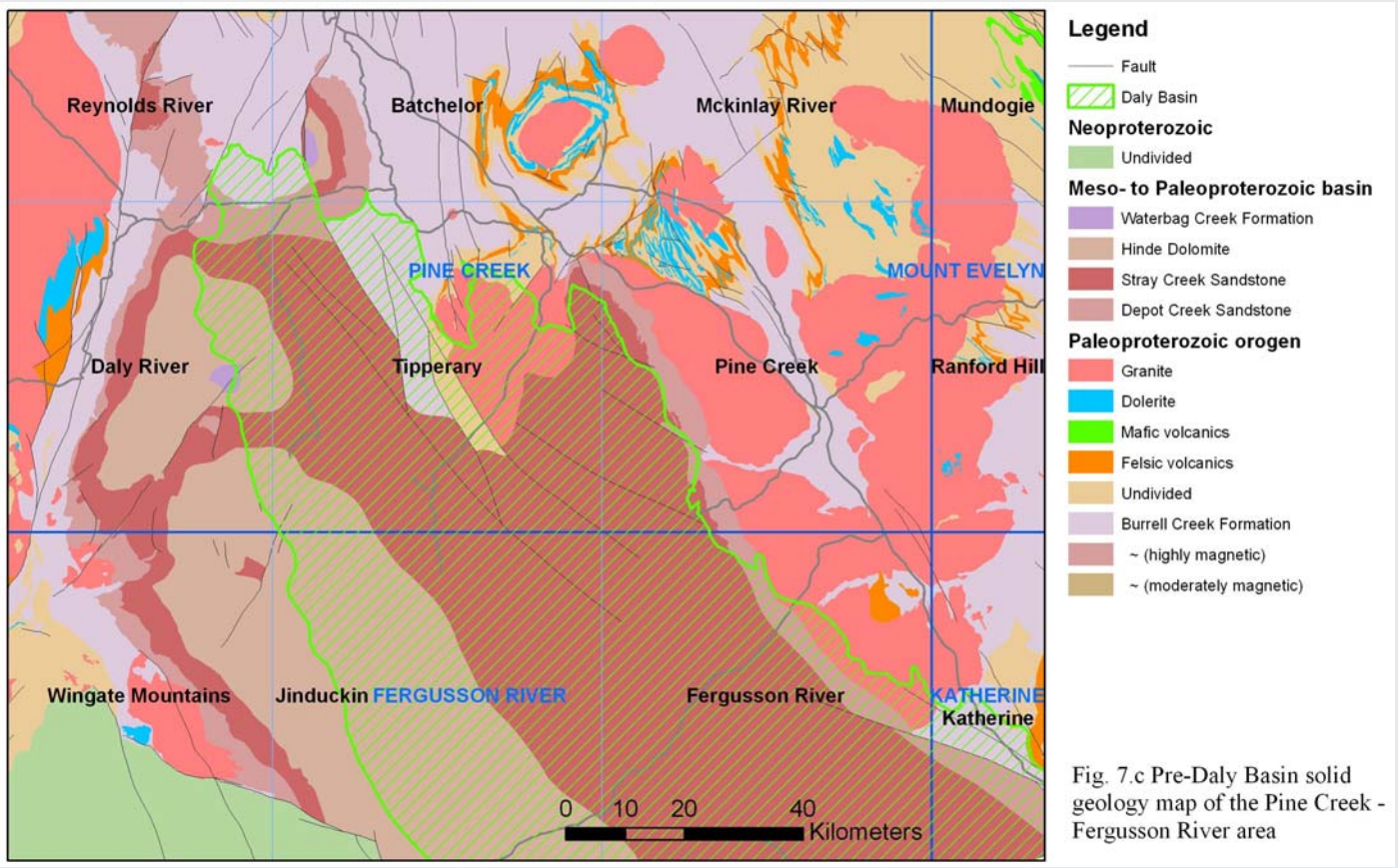


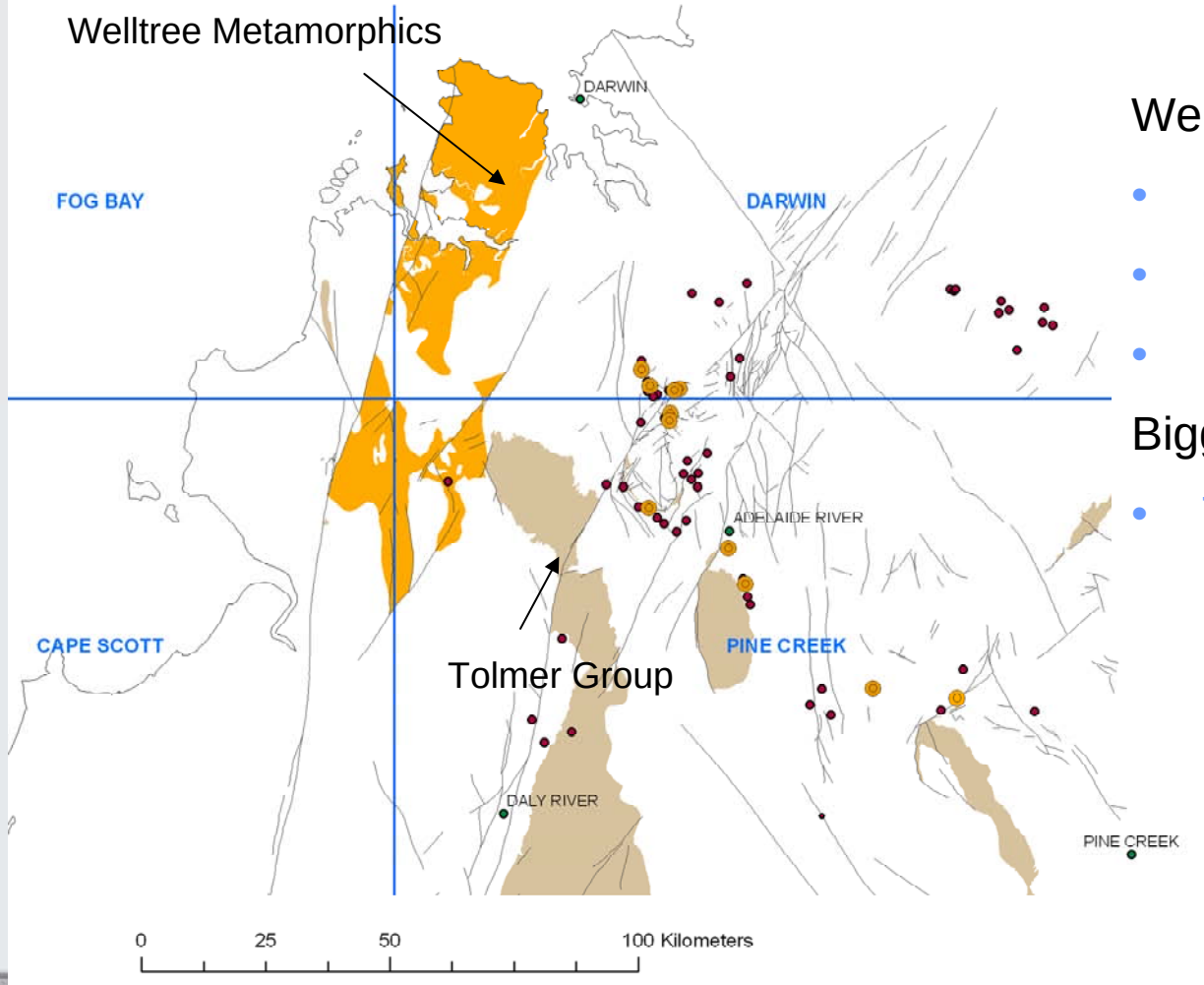
Fig. 7.c Pre-Daly Basin solid geology map of the Pine Creek - Fergusson River area

- Covered by Daly Basin: Depot Creek Sst <100 m at margins, but >500 m in central part of the Basin
- Absence of Archean granite – gneiss complex (?)
- Absence of mafic and/or felsic magmatism (of similar age to Oenpelli Dolerite)

Future work

- 3D model of Daly Basin & underlying Proterozoic
- Improve solid basement geology: details from drill holes
- Depot Creek Sst: age, diagenetic history & provenance of sediments: to estimate pre-erosion extent of Tolmer Gp
- Evaluate presence of Archean

Unconformity Between Tolmer Group and Welltree Metamorphics



Welltree Metamorphics

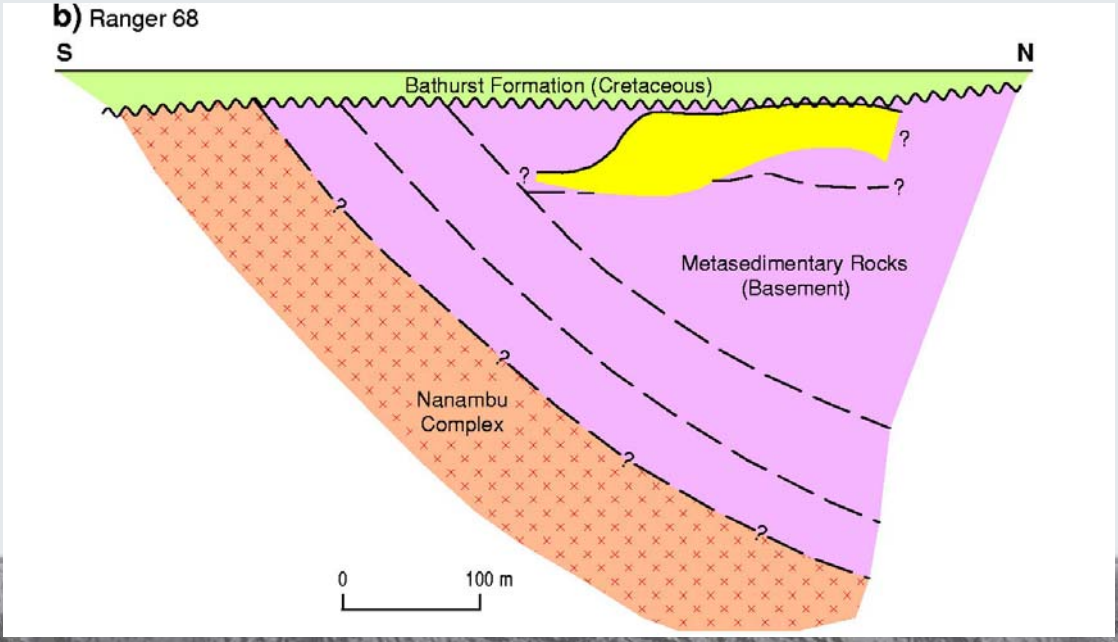
- Upper-amphibolite facies
- Graphitic
- Chloritic

Biggest unknown

- Tolmer Group
  - Extent
  - Diagenetic history

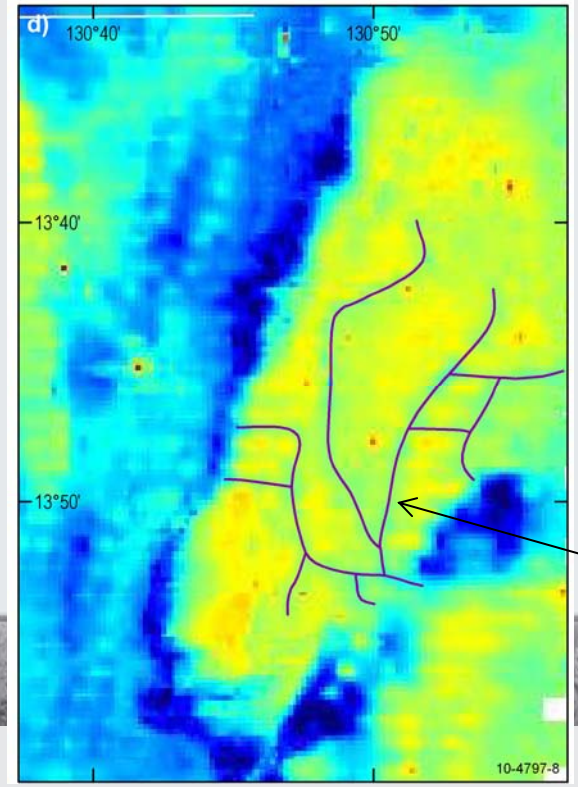
Other Unconformity-U Systems

- Fitzmaurice Basin (especially unconformity between The Fitzmaurice Group and the Hermit Creek Metamorphics)
- The unconformity between Cretaceous sandstone and Proterozoic metasediments (Ranger 68, Austatom?)



Sandstone-Hosted Uranium

- Cambrian (Jindare Formation):
  - Reductant?
- Cretaceous
  - Mostly marine
  - Basal parts fluvial
- Cenozoic
  - No information
  - Paleovalley and/or paleochannels not mapped
  - Infill sediments not known



Daly Basin area

Paleochannels?

Conclusions

AEM survey and review of mineral systems

- Prospectivity of known areas confirmed
- New prospective areas defined
  - Daly Basin
  - Welltree Metamorphics/Tolmer Group unconformity
- Future work:
  - Pre-erosion extent of Katherine River and Tolmer groups
  - 3D architecture of basins
  - Diagenetic history of sediments
- Sandstone-hosted uranium deposits in PCO (?)