Mineral systems and tectonic evolution of the North Australian Craton

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Acknowledgments

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Colleagues at NTGS and GSWA
Purposes of this talk

To extend outward new knowledge from the Tanami, Tennant, Aileron and Warumpi Provinces

To relate mineral systems to the evolution of the North Australia Craton

To predict possible new mineral systems

To identify new directions for future research
North Australian Craton – event systems

2680-1920 Ma: Basement growth
  1920-1840 Ma: ESE-dipping subduction
  1840-1835 Ma: Kimberley-NAC collision
  1835-1825 Ma: deformation of foreland (?) basin
  1825-1790 Ma: transition from activity on NW margin to S margin

1790-1745 Ma: N-dipping subduction

1790-1745 Ma: Calvert basin

1730-1690 Ma: Basement growth
  1690-1640 Ma: Growth of Warumpi Province
  1640-1610 Ma: Collision and exhumation of Warumpi Province

1640-1575 Ma: Rift-related and passive margin sedimentation in east and north
2680-1920 Ma – basement

2680-2470: Granite-gneiss complexes and metamorphic complexes

2050-2020 Ma: immature siliciclastic, carbonates and volcanic rocks

Possible mineral deposits: Browns at ~2030 Ma
Willowra suture (?) – seismic evidence
Willowra suture (?) – diamond potential

125 km seismic tomography
1920-1840 Ma – southeast dipping subduction
1920-1840 Ma – southeast dipping subduction

Sheppard et al. (2000)
Extent of 1865-1860 Ma basins

Basin phase I is not geographically continuous
Does lack of continuity for basin phase I indicate segmented basin system?

Possibly filling bottom of half grabens?

Related to back-arc extension on continental crust?
1850-1845 Ma – IOCG mineralisation

Tennant Creek:
1850-1845 Ma
Associated with magnetite-rich sediments
Coeval with rapakivi magmatism

Tanami (??):
Magnetite-rich sediments (Ferdies Member)
1844 Ma Inspiration Peak Granodiorite
1920-1840 Ma – other mineralisation

**Pine Creek**
VHMS (1862 Ma)

**Halls Creek**
VHMS (1880 Ma and 1845 Ma)
Mafic-ultramafic
Ni-Cu and PGE (1857-1844 Ma)
1840-1835 Ma – Collision of Kimberley Craton

Basin phase II
Foreland basin (?)
Thinning of Tanami-Lander Package to southeast

Basin developed on continental crust (Nd and Pb isotopes)

Sediments sourced from north and west

Basin system appears to be continuous

Mineral potential: Sullivan-type Zn-Pb (?)
1835-1825 Ma – Deformation of foreland basin

Collision of Kimberley Craton
NNE-SSW trending anticlines—earliest deformation?

Some evidence for early (~1830 Ma) lode gold

Prepares architecture for later gold mineralisation
1825-1790 Ma; transition from activity on NW margin to S margin

Northern Tanami: subareal volcanics

Southwest Tanami: marine turbidites

Davenport: subareal volcanics

Southeast Aileron: marine volcanioclastics
1820-1800 Ma – Basin phase III

Segmented basin system

Basins have quite different fill – subareal and marine; volcanic and siliciclastic

Local extensional or transpressive basins?

Ongeva (southeast Aileron) package consistent with back-arc basin
East-west structuring

Consistent with stress from south
Mineral potential – 1825-1790 Ma

Volcanic-hosted massive sulphide deposits — Ongeva package

Low sulphidation Au-Ag and high sulphidation Au-Cu epithermal systems – northern Tanami and Davenport

Advanced argillic alteration assemblages reported by D Blake

Vein silver deposits in Davenport region

Lode gold – Pine Creek, Tanami and northern Aileron
~1790 Ma lode gold, North Australia Craton

- Pine Creek: >8 MOz Au
  - Age: ~1780 Ma

- Tanami: >10 MOz Au
  - Age: 1800-1790 Ma

- Dodger
  - Age: ~1790 Ma

- Kurinelli
  - Age: <1810 Ma
Controls on ~1790 Ma lode gold

Pre-structuring of Tanami Group, Pine Creek: collision of Kimberley from northwest; stress from south

Existence of favourable host units – BIFs and carbonaceous sediments in condensed sections of deep water basins

Coeval tectonothermal disturbance at ~1790 Ma (granites and deformation)

Gold and granites: symptoms of same disease
1790-1690 Ma – contrast between east and south

Mt Isa Inlier

1790-1745 Ma: Initiation and closure of Leichhardt Superbasin
ENE-WSW extension produced N-S basins
Mafic volcanic rocks and siliciclastics; minor carbonates

1730-1690 Ma: Initiation and closure of Calvert Superbasin
NE-SW extension – linked to Strangways event
Bimodal volcanism cumminating with Sybella Granite
1790-1690 Ma – contrast between east and south

Southern Margin of Aileron Province

1790-1745 Ma: North-dipping subduction

Yambah thermal event: 1790-1770 Ma granites
Supracrustal rocks very restricted (Reynolds package?)

Inkamulla thermal event: 1770-1745 Ma granites
1765-1745 siliciclastic and volcaniclastic rocks

1730-1690 Ma: Strangways Event

High T-low P metamorphism in south
Granite emplacement towards north
1790-1690 Ma – (potential) mineral systems

Leichhardt Superbasin
No known mineralising system
Source rock for Mt Isa-type mineral systems
Potential for Sullivan-type Zn-Pb deposits

Calvert Superbasin
No known mineralising system
Potential for Sullivan-type Zn-Pb deposits

Yambah Event
IOCG deposits

Inkamulla Event
Carbonate replacement Zn-Cu deposits

Strangways Event
Skarn, carbonate replacement Sn-W-Mo deposits
Australian Proterozoic apparent polar wander path

1653 Mount Isa

1665-1675

Century

?1575

1640

HYC, Browns, U deposits

Idnurm (2000)

Broken Hill, Cannington, Pegmont, Dugald River
<table>
<thead>
<tr>
<th>Broken Hill-type versus Mt Isa-type Zn-Pb-Ag deposits</th>
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<tbody>
<tr>
<td>Broken Hill-type</td>
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<tr>
<td><strong>Basin</strong></td>
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<tr>
<td>Ensialic rift: siliciclastic dominated; minimal</td>
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<tr>
<td>carbonates; bimodal magmatism</td>
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<tr>
<td><strong>Metal assemblage</strong></td>
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<tr>
<td>Pb-Zn-Ag(Cu-Au)</td>
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<tr>
<td><strong>Regional alteration</strong></td>
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<tr>
<td>Albitic; oxidised (high Fe₂O₃/FeO)</td>
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<tr>
<td><strong>Fluids</strong></td>
</tr>
<tr>
<td>High T (200-300°C), reduced</td>
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<tr>
<td><strong>Depositon</strong></td>
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<tr>
<td>(Near) syngeneric</td>
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<tr>
<td><strong>Pb isotopes</strong></td>
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<tr>
<td>Relatively primitive</td>
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</tbody>
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Cooke et al., 2000; Huston et al., 2006
Pb isotope data – variations in μ (CSIRO-AGSO model)
Australian Proterozoic apparent polar wander path

Idnurm (2000)
Mt Isa eastern succession

1680-1670 Ma Maronan Group

Rift-related turbidites

Amphibolite and metabasalt, minor felsic volcanic rocks

Coeval with emplacement of Sybella Granite in western succession

Regional albitic alteration

Host to Cannington and Pegmont BHT deposits
Australian Proterozoic apparent polar wander path

Idnurm (2000)
Mt Isa western succession

1670-1590 Ma Isa Superbasin

Sag basin on passive margin

Lower siliciclastic abundance; high carbonate abundance; minimal volcanics

Post-dates Maronan Group

Regional K-feldspar-hematite alteration

Host to Mt Isa, Hilton, HYC and Century deposits
Australian Proterozoic polar wander path bends

1653 Ma: Mt Isa and Hilton deposits
   No apparent trigger in present North Australia Craton

1640 Ma: HYC Zn-Pb deposits; U-Th deposits
   (Westmoreland and Killi Killi Hills)
   Triggered by accretion of Warumpi Province

1575 Ma: Century Zn-Pb deposit
   Triggered by Chewings Event

Mt Isa-type and U deposits require circulation of oxidised fluids \( \rightarrow \) Coeval evolution of mineral systems?
Known deposits: epigenetic deposits in 1620-1610 Iwupataka Metamorphics

Potential: 1690-1660 Ma Haasts Bluff domain; felsic volcanism in arc outboard of NAC (VHMS)

Potential: ~1660 Ma Yaya Domain; Fore-arc basin with contemporaneous mafic volcanism (BHT)

Potential: ~1640 Ma Webb region; oxidised granites and associated alteration (IOCG)

Potential: ~1635 Ma Mafic intrusion-hosted Ni-Cu

Potential: Lode Au on NAC
Post-1610 Ma “intracratonic” events

1590-1560 Ma Chewings/Early Isan Event
- IOCG deposits, Mt Isa Eastern Succession
- IOCG deposits, Gawler Craton

~1130 Ma Teapot Event
- Alaska-type PGE

~730 Ma carbonatites

Neoproterozoic-Palaeozoic basins
- Mississippi Valley-type deposits
- Broken Hill-type deposits: Harts Range Group

450-300 Ma Alice Springs Orogeny
- Lode gold deposit
- REE-U deposits
Future work – Tanami region
Quantitative structural chronology
Chronology and relationships in bottom Tanami stratigraphy
Stratigraphic drilling
Extension of seismic line across Hall Creek

Future work – North Australia Craton
Correlation of event systems through regions

Future work – exploration
Thanks

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