Finding mineral potential in greenfields regions with structural geophysical interpretation, west Kimberley, Australia

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Understanding regional prospectivity

Five steps to generate a knowledge driven mineral prospectivity map

1. Preliminary Research
   - Mineral system model
   - Regional geology
   - Data collection

2. Interpretation
   - Petrophysics
   - Structural interpretation
   - Joint forward modelling

3. Selection of evidence layers
   - Source
   - Pathway
   - Trap

4. Evidence layers
   - Preparation
   - Categorise
   - Standardise

5. Model calculation
   - Mineralisation favourability
   - Fuzzy Logic
   - Inference network

Lowell & Guilbert, 1970
Knox-Robinson & Wyborn, 1997
Lindsay et al. 2014
The west Kimberley: King Leopold Orogen and Lennard Shelf

After Tyler et al. (2012)
The west Kimberley: King Leopold Orogen and Lennard Shelf

• **Hooper Orogeny**
  1870-1850 Ma
  - Hart/Carson LIP
    • Follows c. 1820 Ma Halls Creek Orogeny (east Kimberley)

• **Yampi Orogeny**
  <1400 Ma – 800 Ma

• **King Leopold Orogeny**
  c. 560 Ma
The west Kimberley: King Leopold Orogen and Lennard Shelf

- Marboo Formation
- Paperbark Supersuite
- Whitewater Volcanics
- Speewah Group
  - Carson Volcanics
- Kimberley Group
- Hart Dolerite
- Wotjulum Porphyry
- Oscar Range Group
- Devonian limestone units

Modified after Johnson 2013
West Kimberley – architecture and evolution

- **Domain-based structural interpretation**
  - Aeromagnetic and gravity data
    - Events defined on the basis of local overprinting relationships
    - Grouped into regional tectonic events based on field observations, magnetic stratigraphy, structural grain, deformation, and orientation

Tyler and Griffin, 1990
Petrophysical data

Density

Magnetic susceptibility

Log magnetic susceptibility ($10^{-3}$ SI)

Density (g/cm$^3$)

Carson Volcanics

Hart Dolerite

H.D. Granophyre

Ruins Dolerite

Kongorow Granite

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West Kimberley – geophysical interpretation
West Kimberley – geophysical interpretation
West Kimberley – forward modelling

Joint magnetic and gravity modelling

Magnetic response

Gravity

SW

NE

Inghis Fault

Inghis Fault

Inghis Fault

Canning Basin

King Leopold Orogen

Kimberley Block

Magnetic

Gravity

SW NE

SW NE
West Kimberley mineral prospectivity

- Multi-commodity regional prospectivity analysis
  - Nickel sulphide
  - Orogenic gold
  - Intrusion-related base metals, MVTs, epithermal Au, stratiform-hosted base metals, Sn-W

- Mineral Systems Approach
  - “Predictor” maps representing metallocotects combined using a fuzzy inference network
  - Provide an indication of relative geological favourability for deposits, not a probabilistic prediction of actual deposit locations
  - Influenced by the imperfect data distributions and genetic model

*MORE DETAILS IN THE POSTER RED 63 (ERE3.1/GMPV14/TS9.6 17h30 – 19h00 tonight)*
# West Kimberley mineral prospectivity

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Source evidence layers combined with fuzzy OR</th>
<th>Pathway evidence layers combined with fuzzy OR</th>
<th>Trap evidence layers combined with fuzzy OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ni-sulphides</td>
<td>Distance to Hart Dolerite 0.81</td>
<td>Mantle-tapping faults 0.63</td>
<td>Fault intersection density 0.4</td>
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<tr>
<td></td>
<td></td>
<td>Post faults (E4 C2 E5 C3 E6) 0.56</td>
<td>Fault jogs density 0.45</td>
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<td></td>
<td></td>
<td>Syn faults (E3) 0.63</td>
<td>Dyke jogs density 0.45</td>
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<td></td>
<td></td>
<td>Dykes 0.63</td>
<td>Alteration index 0.4</td>
</tr>
<tr>
<td>CHBM (Carbonate-hosted base metals)</td>
<td>Distance to Pinnacle Fault System 0.81</td>
<td>Distance to basement high 0.56</td>
<td>Within Devonian Limestone 0.4</td>
</tr>
<tr>
<td>Au – ‘Orogenic’</td>
<td>Distance to Paperbark Suite 0.72</td>
<td>Mantle-tapping faults 0.63</td>
<td>Alteration index 0.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post faults (E2 E3 E4 C2 E5 C3 E6) 0.56</td>
<td>Competency contrast 0.4</td>
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<td>Structural complexity 0.4</td>
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<td></td>
<td>Distance to Ruins Dolerite 0.35</td>
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<td></td>
<td></td>
<td>Distance to Wotjulum Porphyry 0.4</td>
</tr>
<tr>
<td>Sn-W</td>
<td>Distance to Paperbark Suite 0.72</td>
<td>Mantle-tapping faults 0.63</td>
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<td>Syn faults (E3, C1) 0.63</td>
<td>Distance to Hart Dolerite 0.4</td>
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<tr>
<td>Stratiform-hosted base metals</td>
<td>Distance to Marboo Formation 0.72</td>
<td>Post faults (C1 E2 E3 E4 C2 C3 E6) 0.49</td>
<td>Distance to Carson Volcanics 0.4</td>
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<td>Intrusion. Related Base Metals</td>
<td>Distance to Hart Dolerite 0.81</td>
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Combination of weights = fuzzy membership value

Eg. **Inglis Fault Map** (0.9) * confidence (0.7) = 0.63

Distance from Inglis Fault – linear decrease out to 10km

Combined with fuzzy PRODUCT operator

small weights have greatest influence

conservative
West Kimberley Ni-sulphide

- Hart Dolerite
- Inglis Fault
- Dolerite dykes
- Fault jogs
  - dilation zones
  - ?embayements
West Kimberley orogenic Au

- Paperbark Supersuite
- Inglis Fault
- Shear zones
- “Structural complexity”
- Mafic units
Summary – Geophysical structural interpretation

- Provides relatively robust data for input into mineral potential mapping
- Crustal-scale structure focusing mineral prospectivity eg. Inglis Fault
- Prospectivity modified by the presence of acceptable lithological conditions eg. Hart Dolerite
- Northern edge of the Paperbark Supersuite is found to be prospective for multiple mineral systems
- The prospectivity indicates periods of reactivation and magmatic events
- The undercover part of the Oscar Range is found to be prospective for MVT deposits


Johnson, S. 2013 The birth of supercontinents and the Proterozoic assembly of Western Australia: Geological Survey of Western Australia, 78p.

Lindsay, MD, Betts, PG and Ailleres, L (2014) Data fusion and porphyry copper prospectivity models, southeastern Arizona, Ore Geology Reviews.61, 120-140.


Tyler, I. M., and Griffin, T. J., 1990, Structural development of the King Leopold Orogen, Kimberley region, Western Australia: Journal of Structural Geology, v. 12, no. 5-6, p. 703-714.
West Kimberley S-HBM prospectivity

- S-HBM (Stratiform-hosted base metals)
- Marboo
- Kimberley Group
- Speewah

- Alteration index
  - K abundance
  - Apparent susceptibility

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West Kimberley Sn-W prospectivity

- Paperbark Supersuite
- Inglis Fault
- Alteration index
  - K abundance
  - Apparent susceptibility
- Chemical reactivity
West Kimberley IRBM prospectivity

- IRBM (Intrusion-related base metals)
  - Porphyry Cu
- Hart Dolerite
- Paperbark Supersuite
- Inglis Fault
- Second order faults
- Wotjulum Porphyry
- Structurally complex
- Alteration index

K abundance
apparent susceptibility