ALTERATION AND AGE OF THE BROWNS RANGE RARE-EARTH ELEMENT DEPOSITS

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GSWA Open Day

26 February 2016
Rare Earth Elements in WA

- REE located in several places in WA
- Most deposits are located in North WA

Importance of the project:
- Developing tools for new discoveries
- Improve WA prospectivity
- Opportunity to work with the industry
Rare Earth Opportunities

- Not all REE are equal (abundance, value)
- Light-REE are relatively common and lower value
- Heavy-REE are rarer, higher value
- REE are widely used in high tech / “green tech”
- China is the only HREE producer
An emerging REE Province

- Northern WA is an emerging REE province
- Several HREE deposits: (John Galt, Browns Range, Brockman, Killi Killi)
- Also LREE potential (Cummins Range)

- Northern Minerals interested in detectable alteration footprint
- GSWA offered research collaboration to:
  - Improve understanding of REE origin
  - Enhance REE prospectivity in North WA

Rare earth elements deposits and prospects
Mineralization type
- Laterite associated with carbonatite complex
- Hydrothermal vein-hosted
- Felsic volcaniclastic rocks
- Unconformity related
- Highway
- Town

Map showing locations of John Galt, Brockman, Browns Range, Cummins Range, and Killi Killi with markers and lines indicating mining areas and roads.
Location and ...

- North Australian Craton, Tanami Orogen
- West end of dome on WA-NT border
- Several HREE deposits
- Principal resource is Wolverine...
- ...Gambit, Area 5 and many other prospects

a) Map of Tanami-East Kimberley REE deposits; b) Map of the Browns Range deposits
TANAMI COMPLEX

- Palaeo-Mesoproterozoic
- Clastic sediments, volcanic rocks, syn-tectonic granitoids

- Browns Range Metamorphics ("meta-arkose")
- Overlain by siliciclastic Gardiner Sandstone

- Stratigraphy and REE ages poorly constrained
- Related to the granites?

...and setting
Research program

- Confirm nature and distribution of hydrothermal alteration
- Determine age of mineralization

Sampling and data collected:
- Petrography [40 samples] → identify rock type, alteration
- Phosphate geochronology [19 samples] (SHRIMP, U-Pb)
- Hyperspectral scans of core [6 drill cores]
- Company drill assay geochemical data

<table>
<thead>
<tr>
<th>Prospect</th>
<th># of drill-cores</th>
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<tbody>
<tr>
<td>Wolverine</td>
<td>4</td>
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<tr>
<td>Gambit</td>
<td>1</td>
</tr>
<tr>
<td>Area 5</td>
<td>1</td>
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Wolverine

Quartz breccia & vein array

Map view of the Wolverine deposit

(modified after Northern Minerals 2013 ASX releases)
Petrography

Host rock: feldspathic lith-arenite to lithic arkose

Massive to crudely graded, thick bedded, Local pebbly conglomerates units
Petrography

Mineralization: Quartz breccia & xenotime

Open-fill and disseminated Xenotime with hematite dusting
Petrography

Alteration: Clays, Quartz ± Mica

Feldspars adjacent to mineralized zone are replaced by sericite and clays
HyLogger

- Most minerals & alteration cannot be distinguished by naked eye
- Define distribution of REE and associated alteration
- More objective mineral ID and chemistry
- Define significant trends and variations

HyLogger Setup
Age of REE mineralization

Xenotime $[\text{YPO}_4]$ SHRIMP U-Pb age well-constrained $1646 \pm 5$ Ma

Xenotime crystals
Local implications

1646 ± 5 Ma

- Mineralization **younger** than cover rocks
- Granites **much older** than mineralization
- Silica-Clay ± Mica alteration possibly provides a large footprint
- “Alteration exhaust plume” could be detectable using spectral techniques

Stratigraphic column of Tanami region
Regional implications

- Several **similar deposits** in region:
- **Similar** xenotime U-Pb ages
- Broadly **similar age** to NT unconformity-related U
- Suggests **widespread event** (?) 
- **Increased** (H)REE prospectivity for Northern Australian Craton

<table>
<thead>
<tr>
<th>Deposit</th>
<th>Type</th>
<th>Xenotime (U-Pb Age)</th>
<th>Citation</th>
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<tbody>
<tr>
<td>Browns Range</td>
<td>Hydrothermal</td>
<td>1646 ± 5Ma</td>
<td>GSWA, in prep.</td>
</tr>
<tr>
<td>John Galt</td>
<td>&quot;Epithermal&quot;</td>
<td>1619 ± 9Ma</td>
<td>GSWA, in prep.</td>
</tr>
<tr>
<td>Killi Killi</td>
<td>&quot;Diagenetic&quot;</td>
<td>1632 ± 3Ma</td>
<td>Vallini et al. (2007) Min Dep v42 p51-64</td>
</tr>
</tbody>
</table>
Where does the fluid comes from?

No known local driver for REE mineralization

? Related to accretion of Warumpi Terrane to southern Arunta during Liebig Orogeny?
Conclusions

- **REE** in hydrothermal breccias and vein arrays
- **Silica-Clay ± Mica** alteration
- Large alteration footprint
- Mineralization younger than cover rocks
- HyLogger detects **REE** and **alteration**
- Potentially detectable through cover rocks
- Widespread **REE** (±U?) “event”
- North Australia Craton prospective for (H)REE