Rare earth elements secondary prospectivity of mine waste in South Australia

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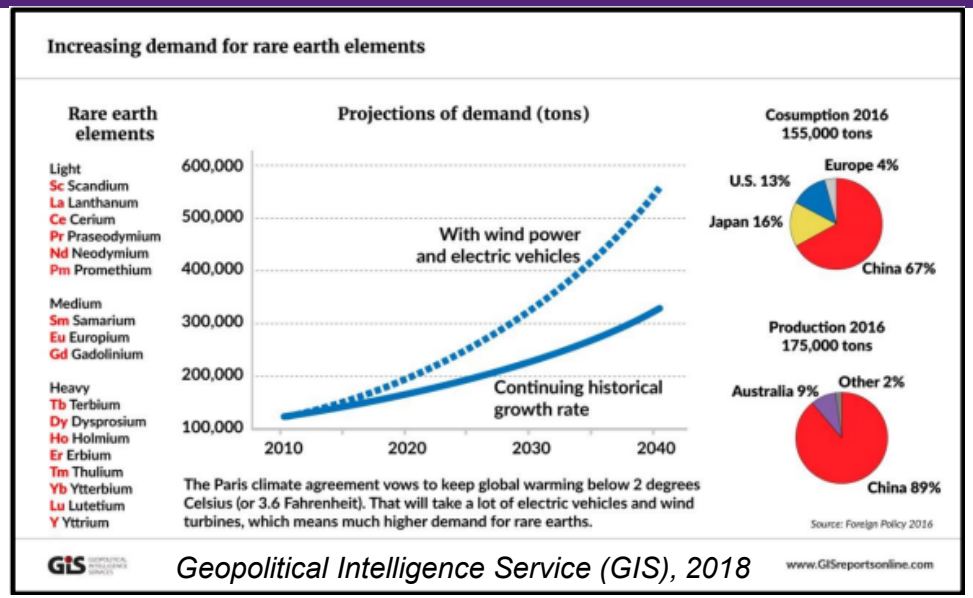
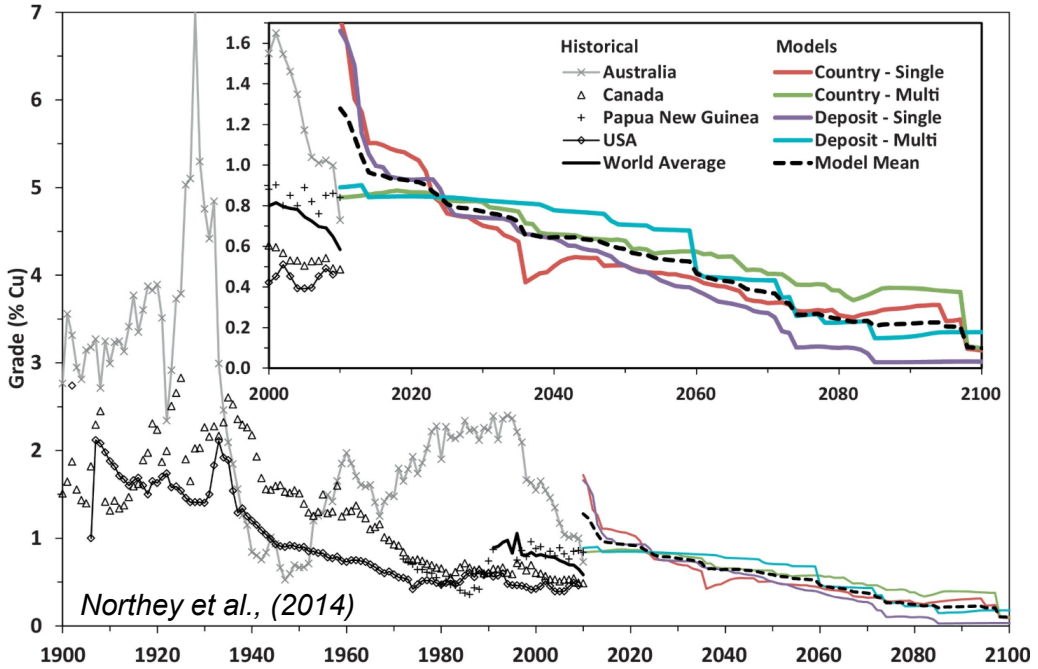
Mine waste- potential resource of critical metals?

- **Global Drivers**
  - Rising demand for critical metals
  - Declining grades & increased mining costs
  - Circular economy policies pushing secondary resources
- **Why Mine Waste is Prospective**
  - Contains residual valuable metals
  - New extraction tech (bioleaching, hydromet)
  - Already disturbed land = lower environmental footprint
  - Reduced exploration and mining costs
- **Examples of Reprocessing**
  - Australia – Zn, Pb, Ag from Mt Isa & Broken Hill tailings
  - Scandinavia – Cu, Co, REE's from historic tailings
  - USA – REE's from iron ore tailings
- **Co-benefits**
  - Mitigating legacy hazards (AMD, dust, leaching)
  - Restore land for reuse
  - Create jobs & value from waste



Geopolitical Intelligence Service (GIS), 2018



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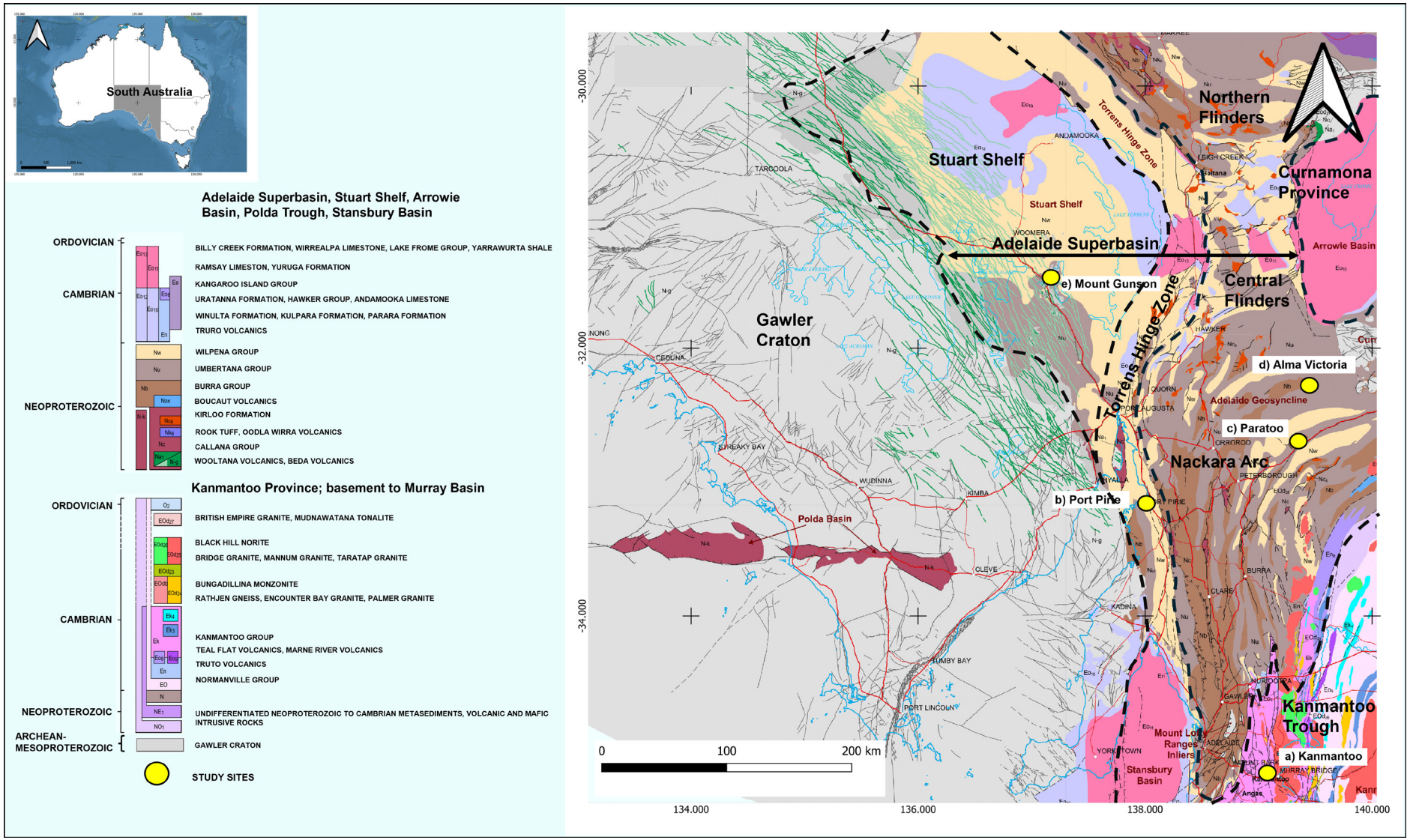
Investigating REE secondary prospectivity of mine waste in SA

- The content and distribution of **critical metals** was investigated at 5 sites in South Australia (SA):

  - Kanmantoo
  - Port Pirie
  - Paratoo
  - Alma and Victoria
  - Mount Gunson



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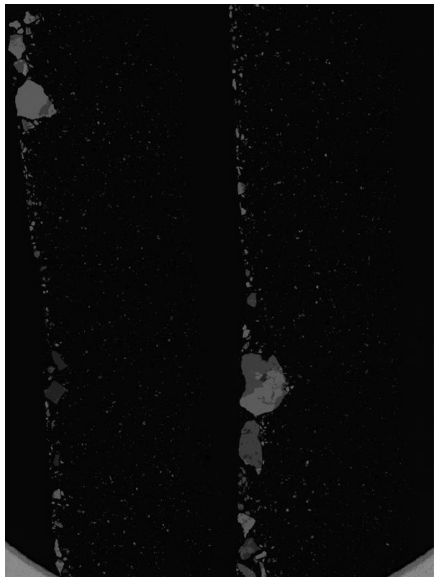
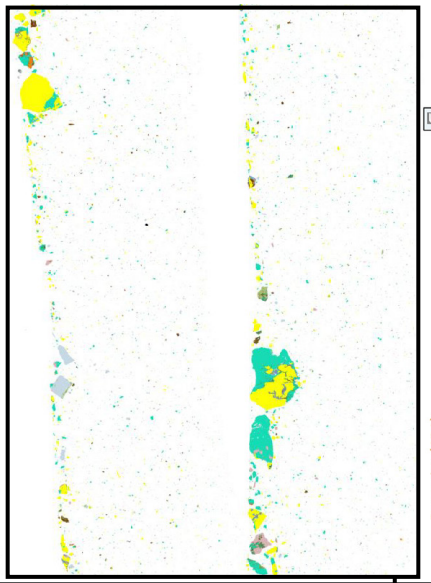
Analytical Approach: ‘Stream 1’

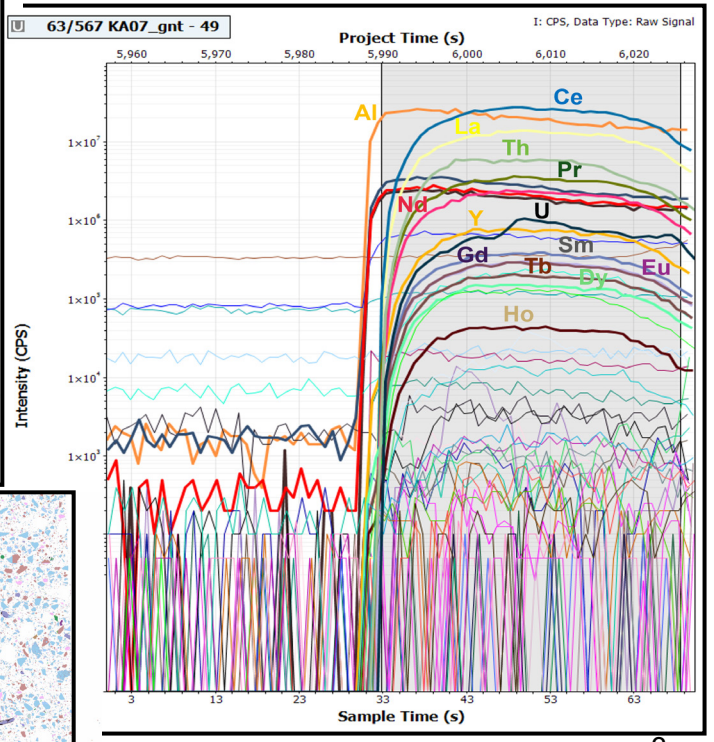
The University Of Queensland
AUSTRALIA

- Mine waste sampling

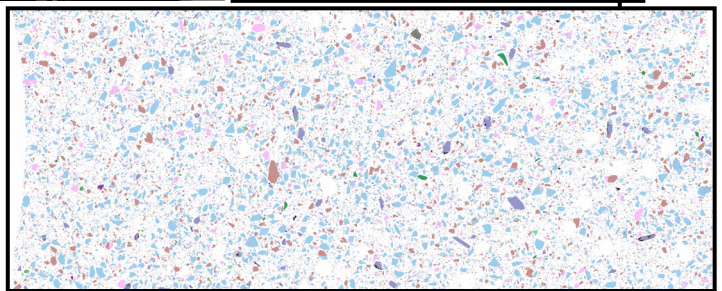
- Chemical assay (48 elements)







- Bulk and in situ mineralogy



- Mineral chemistry (meso/micro-scale)

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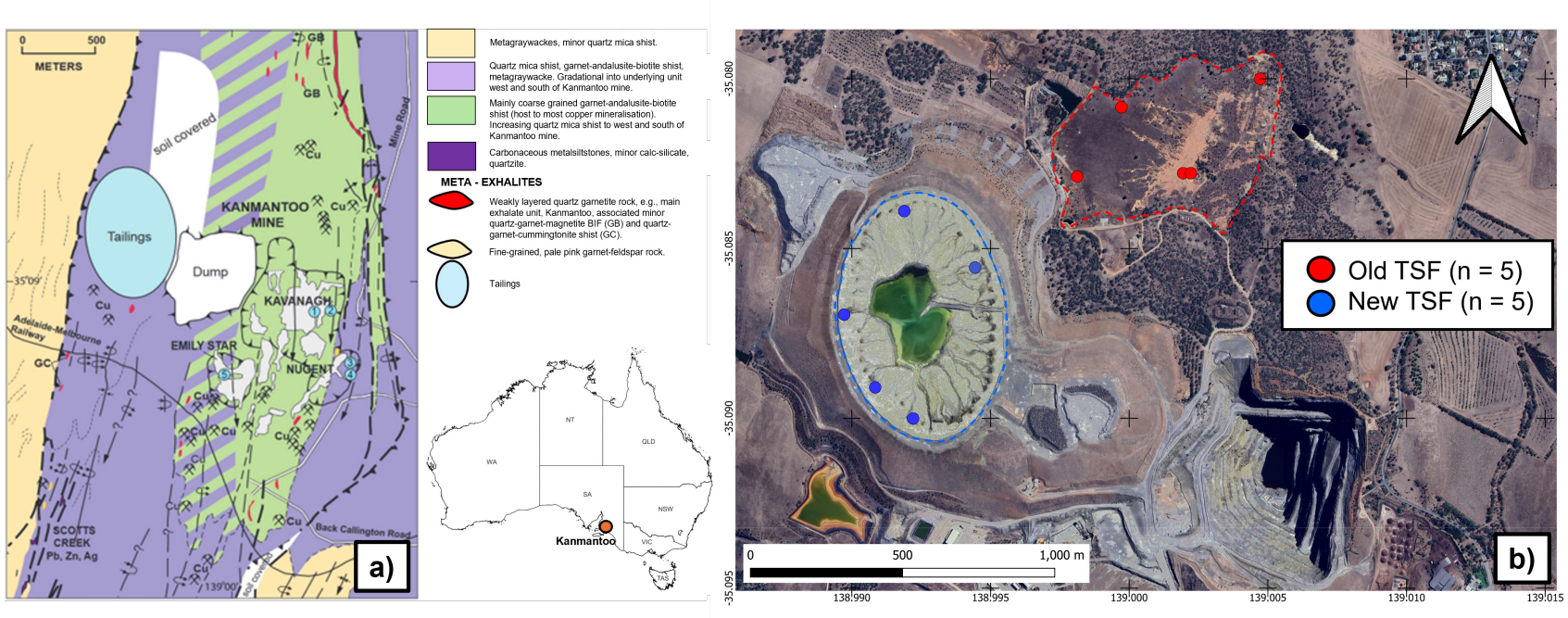
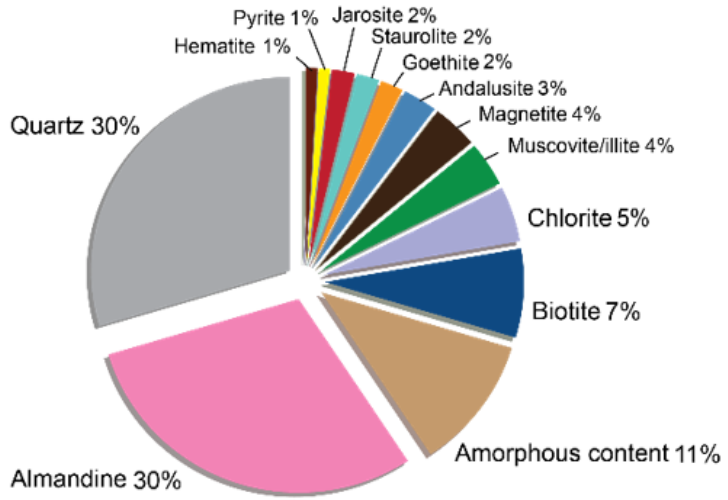
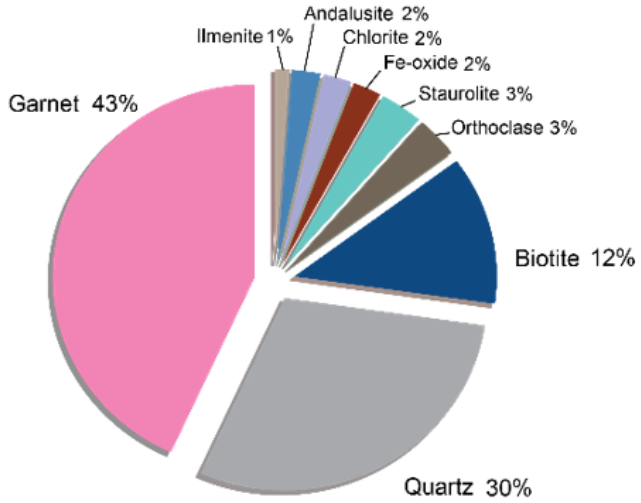
Results: Kanmantoo- Cu-Au-Ag mine



XRD



MLA



- 74 samples (tailings) collected from 10 holes- the old TSF shows a greater colour variability throughout the vertical profile compared to the new TSF
- Elemental average 10 times > average crustal values: **Bi**, **Cu**
- The old TSF exhibits higher concentrations of most metals compared to the new TSF
- Primary minerals identified by XRD and MLA analyses are **garnet** and quartz

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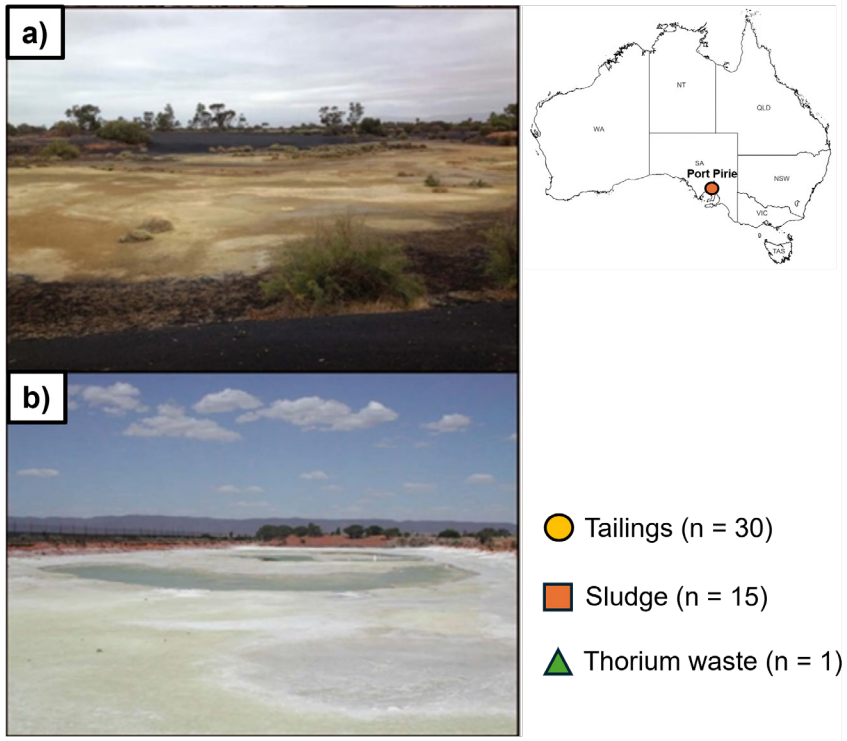
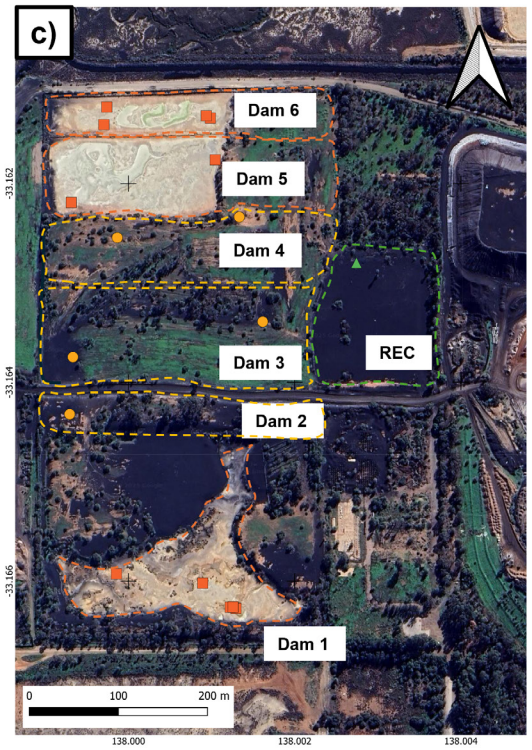
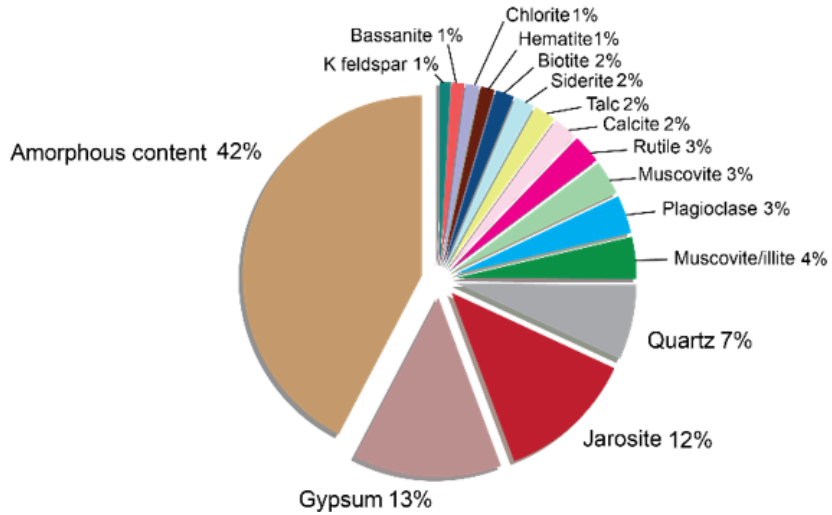
Results: Port Pirie- U and REE treatment facility





XRD



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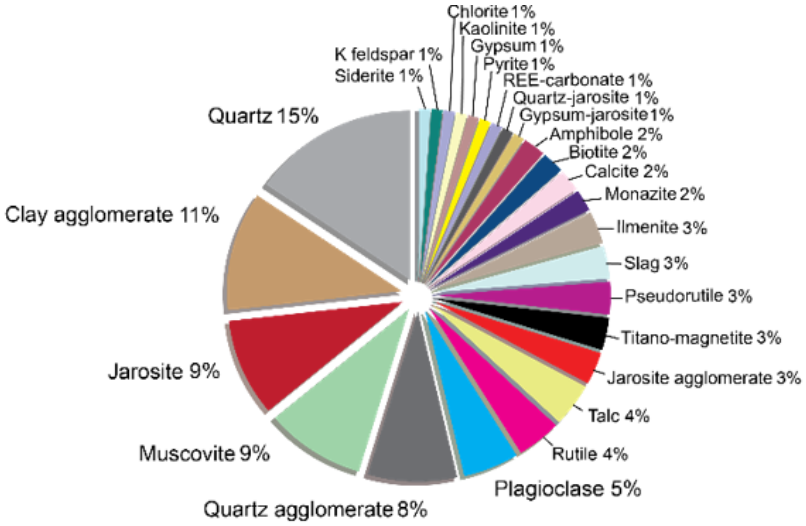

- 46 samples (tailings, sludge, thorium waste) were collected from pre-excavated trenches and 4 holes
- Elemental average 10 times > average crustal values: **Zn, Mo, Pb, U, Th, LREE, HREE** (particularly in the **REC dam**, which contains **thorium-rich waste**)
- Primary minerals identified by XRD and MLA analyses: **gypsum, jarosite, calcite, monazite** and **amorphous material**

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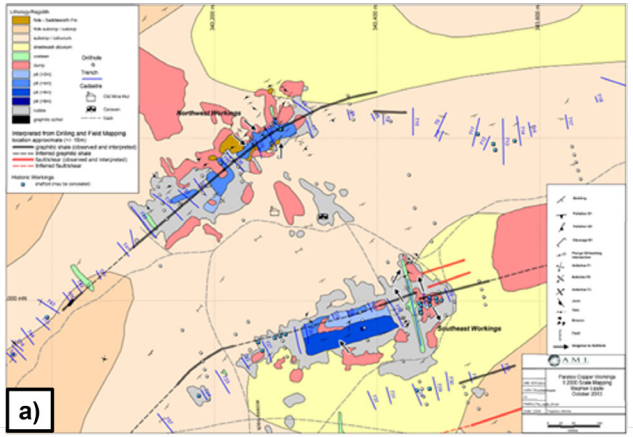
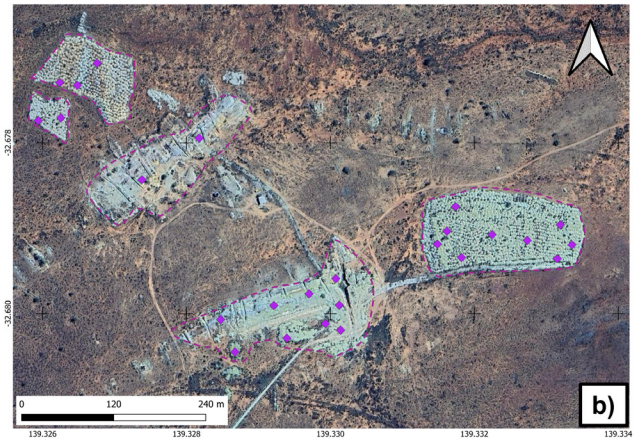
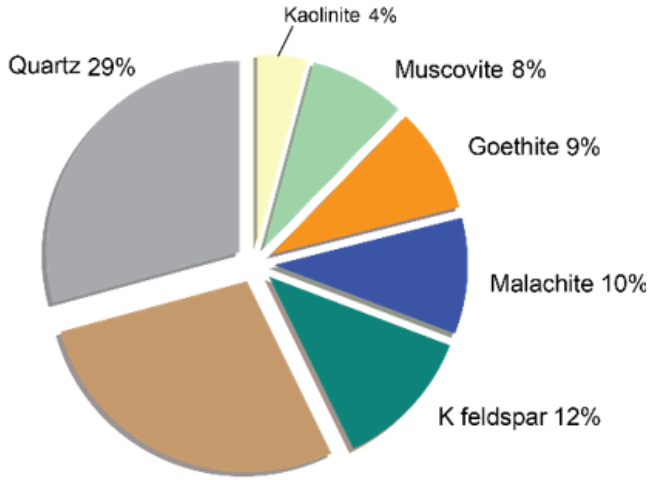
Results: Paratoo- Cu mine





Waste rock (n = 25)

XRD



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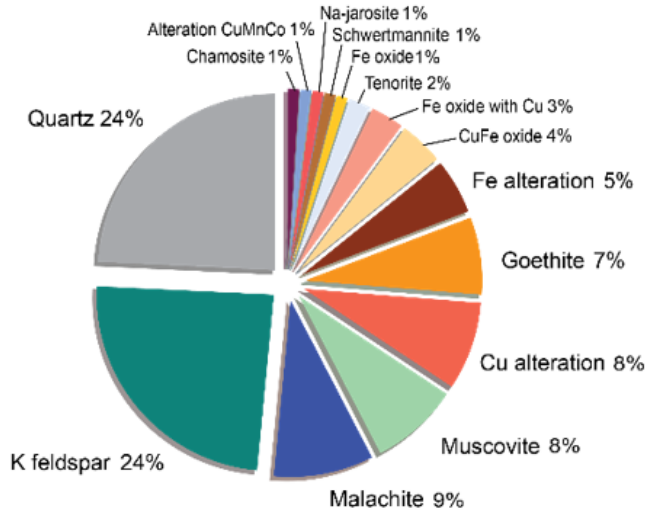

- 25 samples (waste rock) were collected
- Elemental average 10 times > average crustal values: **As, Co, Cu, LREE, HREE**
- Primary minerals identified by XRD and MLA analyses: Quartz, K feldspar, **malachite** and amorphous material

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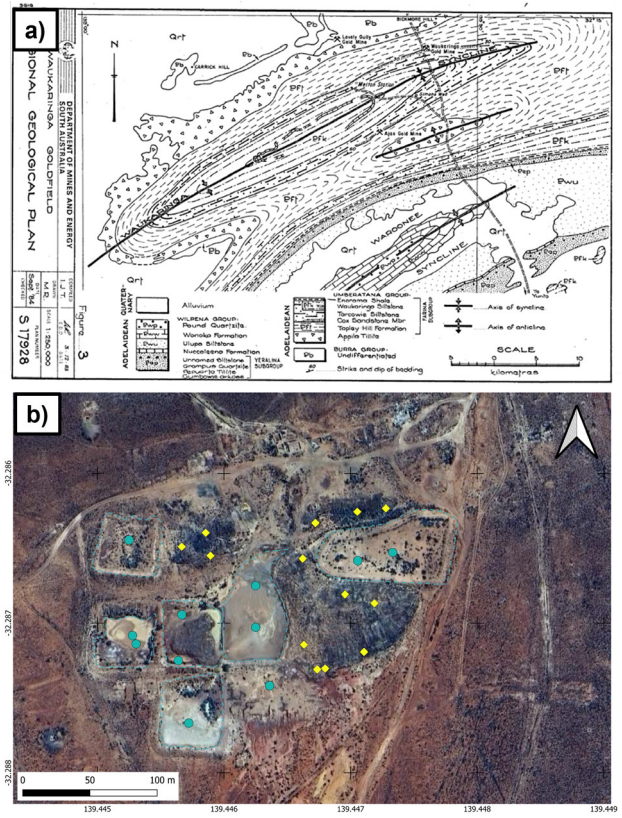
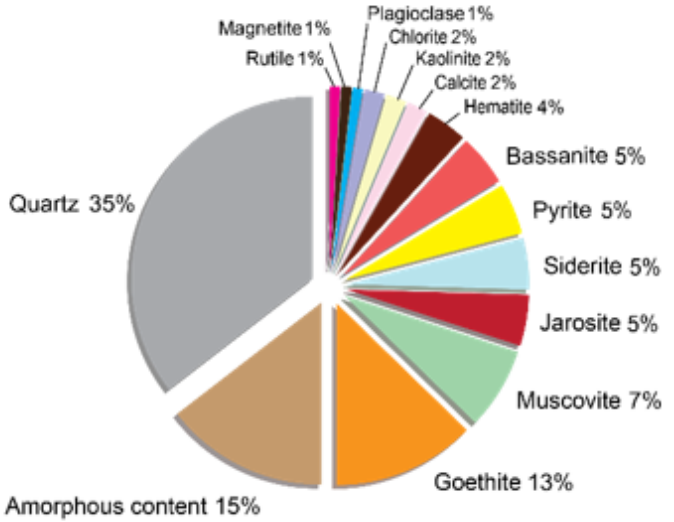
Results: Alma and Victoria Au mine



XRD



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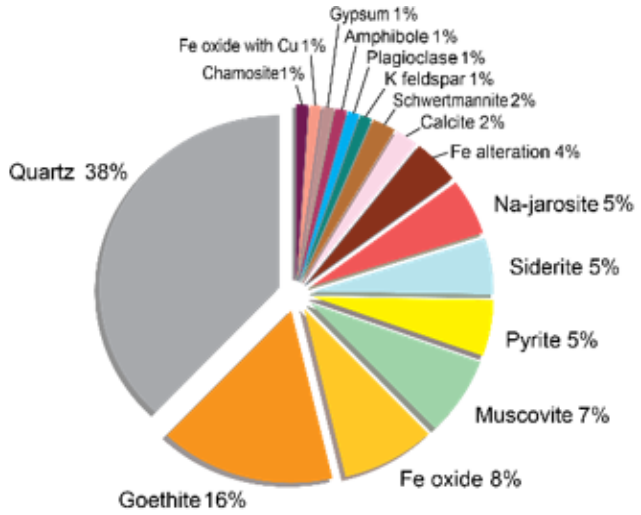

- 80 samples (tailings- n= 67 and waste rock n= 13) were collected from 11 holes and rock dumps
- Elemental average 10 times > average crustal values: **As**, **Bi**, **Cu**, **Pb** (in the tailings)
- Primary minerals identified by XRD and MLA analyses are: quartz, **goethite** and amorphous material. **Pyrite** is a major component in waste rock (up to 40 %)

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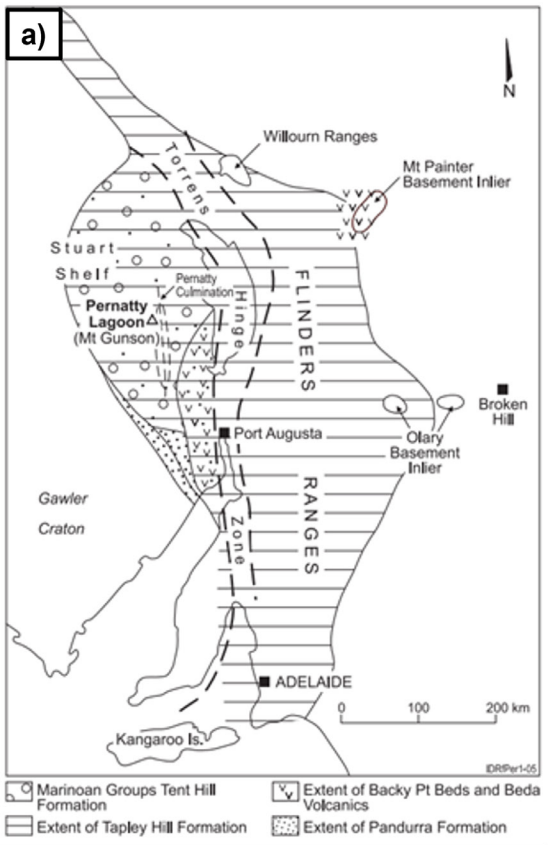
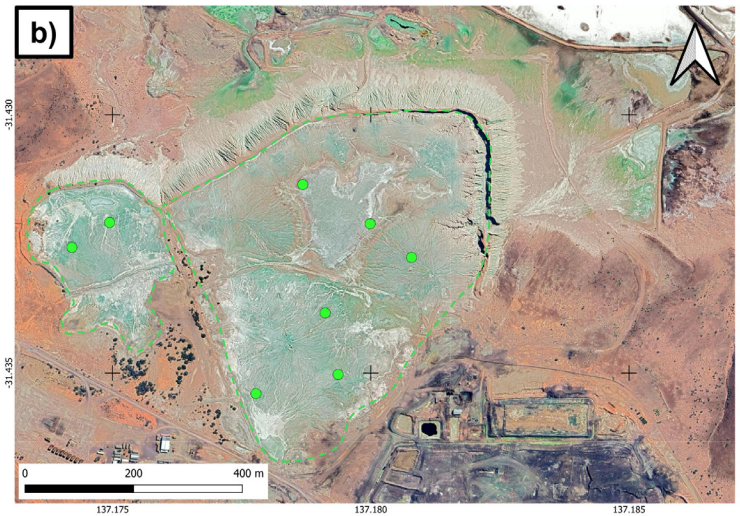
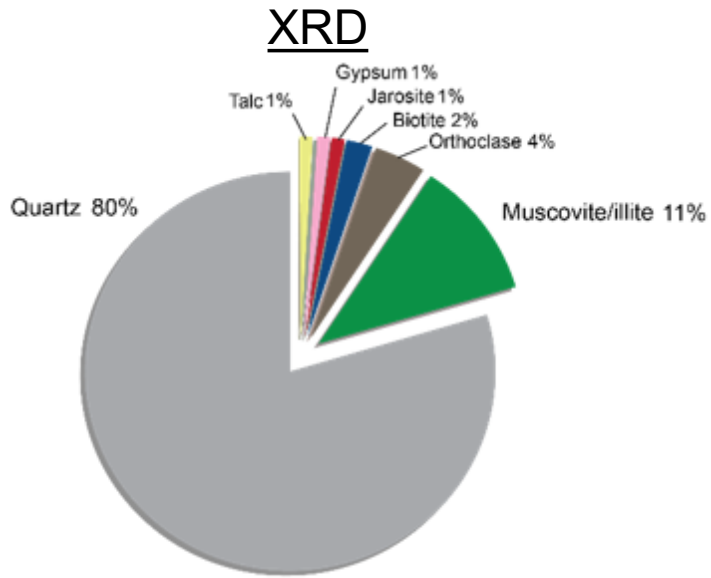
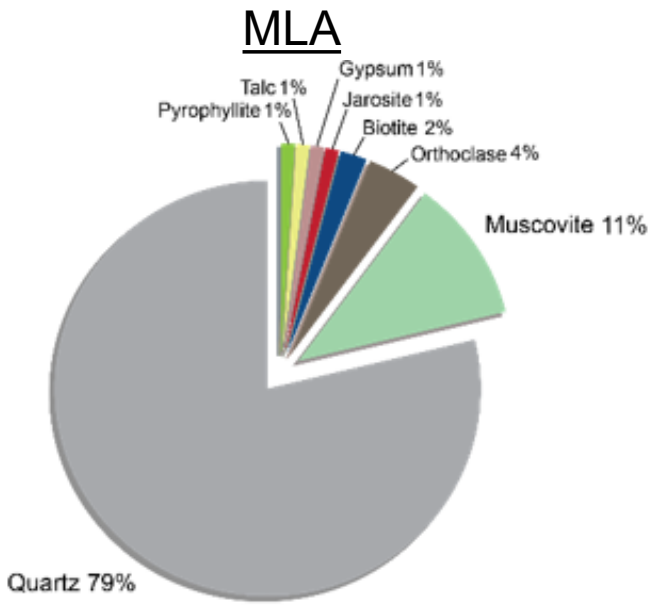
Results: Mount Gunson- Cu-Ag mine



Tailings (n = 62)







- 62 samples (tailings) were collected from 10 holes + efflorescent salts
- Elemental average 10 times > average crustal values: **Ag, Co** (efflorescent salts), **Cu** (tailings)
- Primary minerals identified in by XRD and MLA analyses are quartz and **muscovite**

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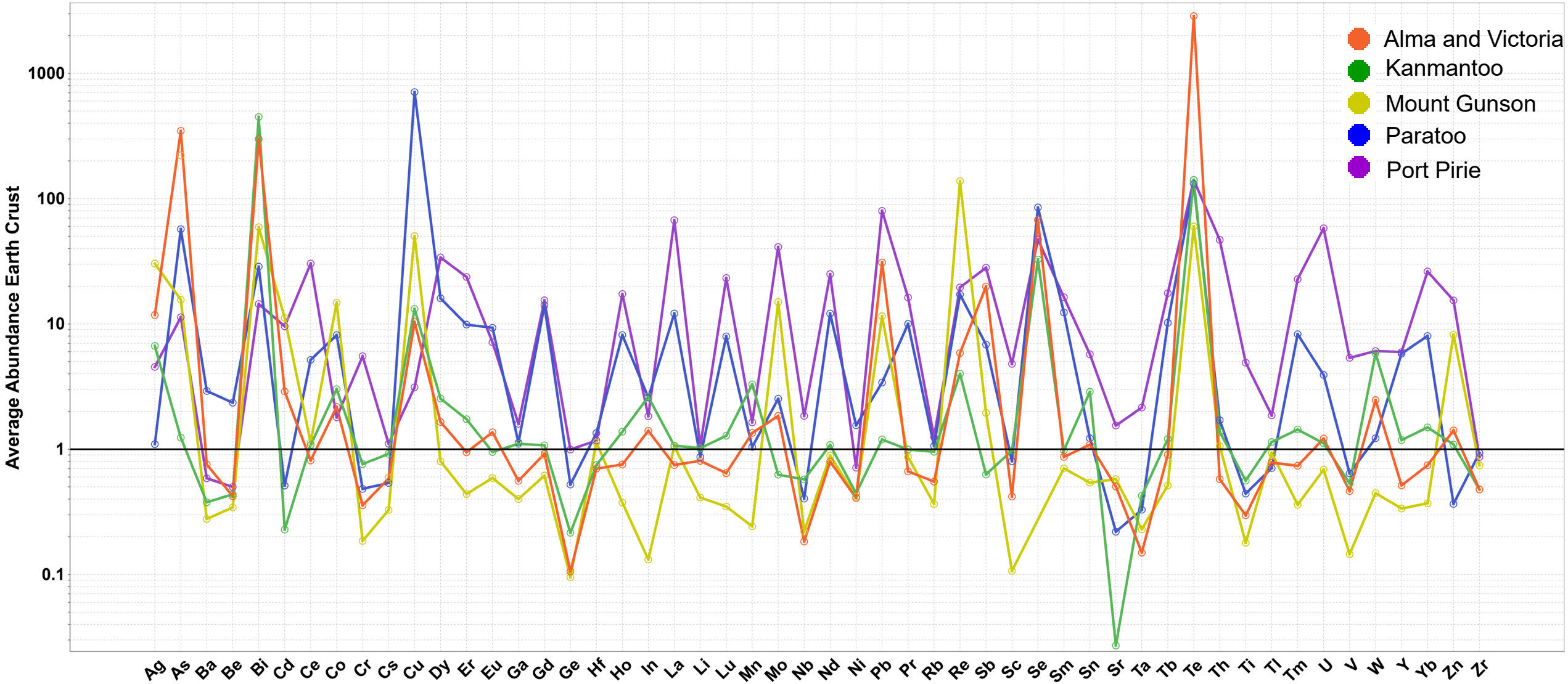
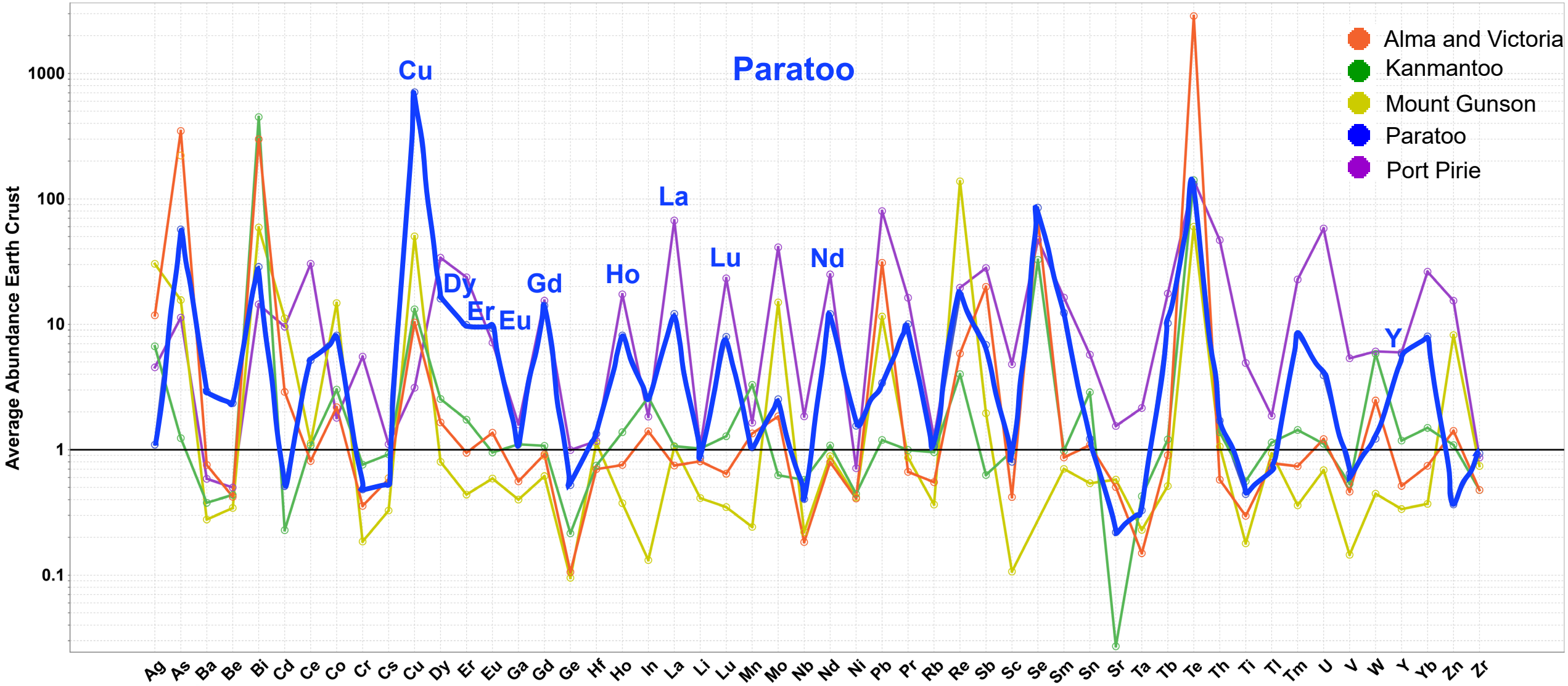
Comparison of geochemical assay data (n= 293)



Comparison of geochemical assay data (n= 293)



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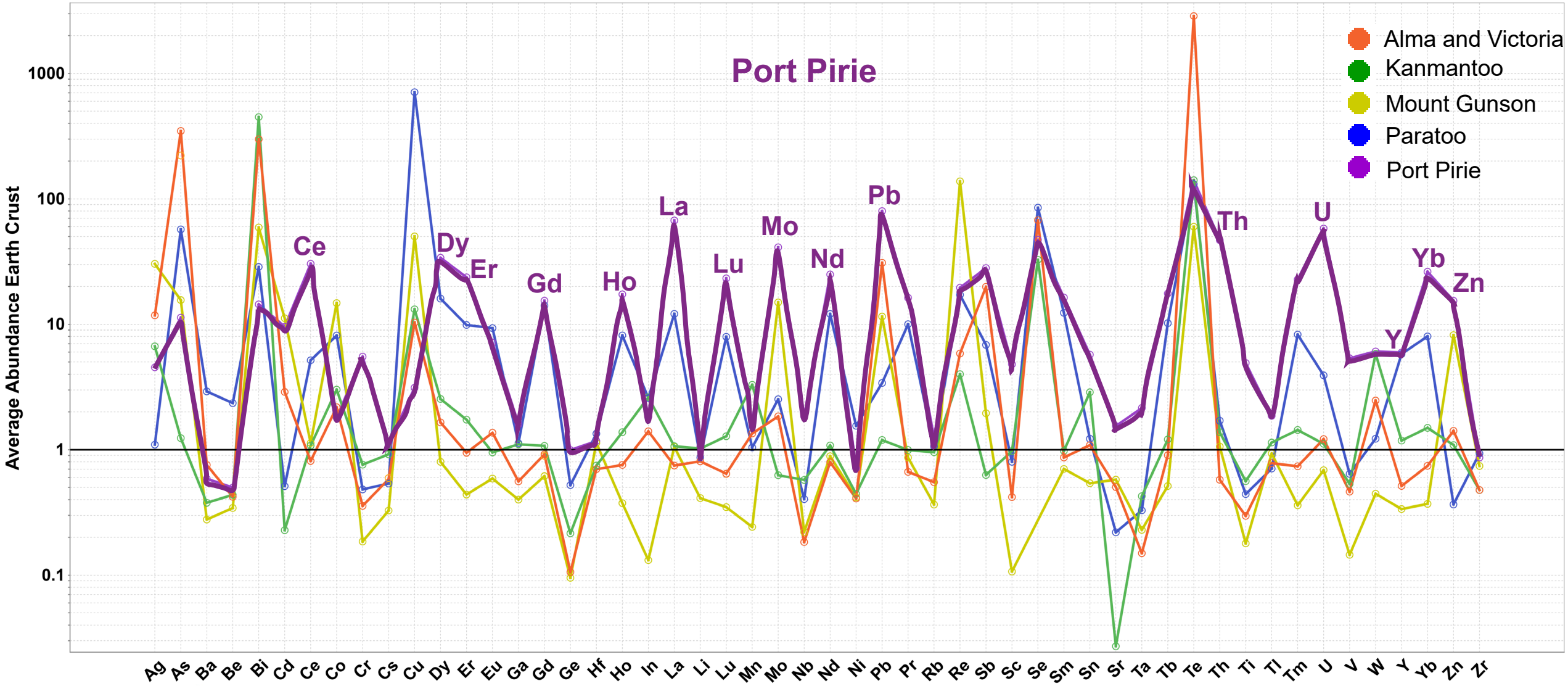
Comparison of geochemical assay data (n= 293)



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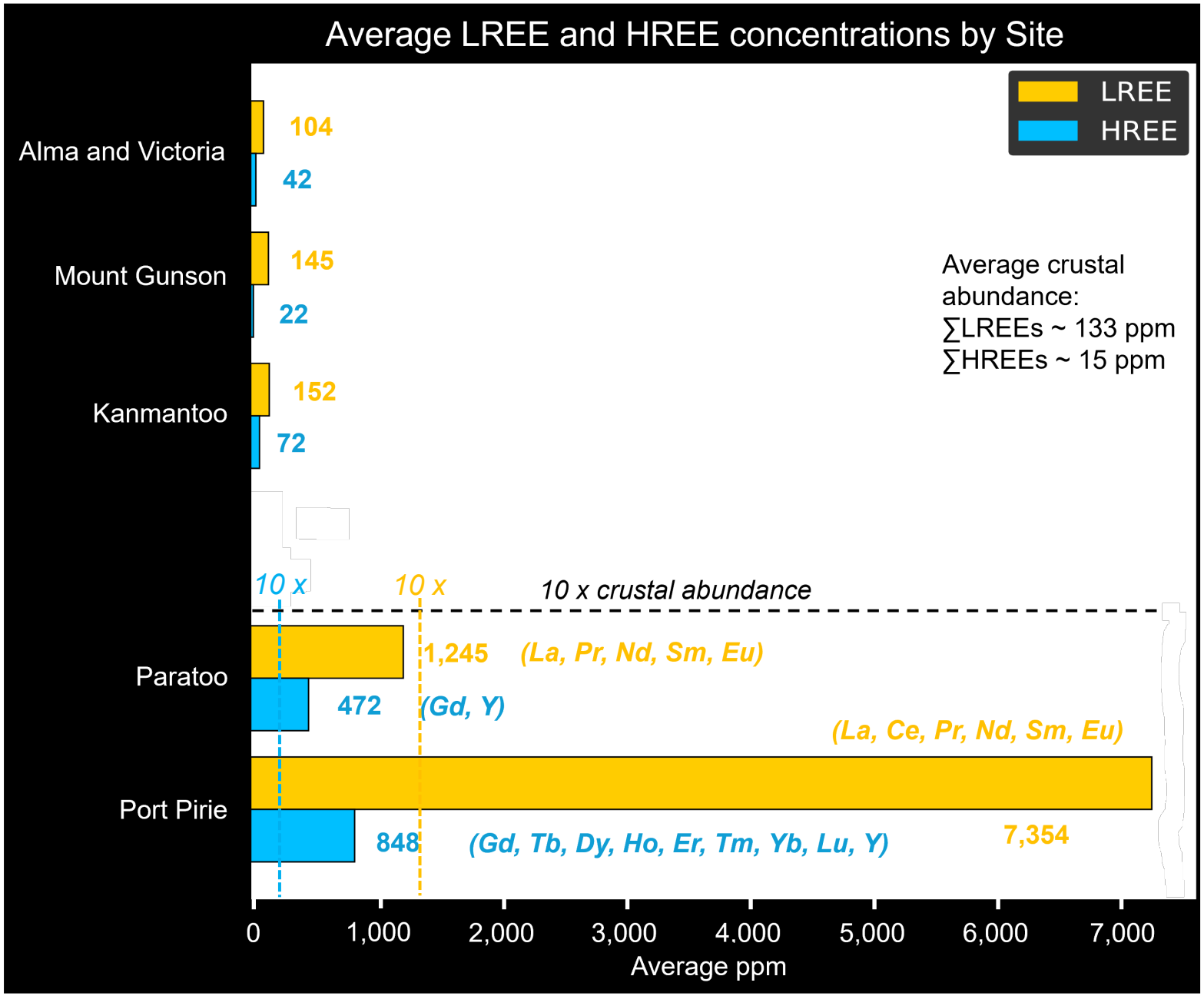
Average concentrations of LREE's and HREE's (ppm) by site

- **Paratoo** and **Port Pirie** display significantly elevated REE's concentrations, more than 10 times crustal averages

- REE's concentrations comparable to lower grade deposits (e.g., Dubbo in NSW with 0.3-1% REO)



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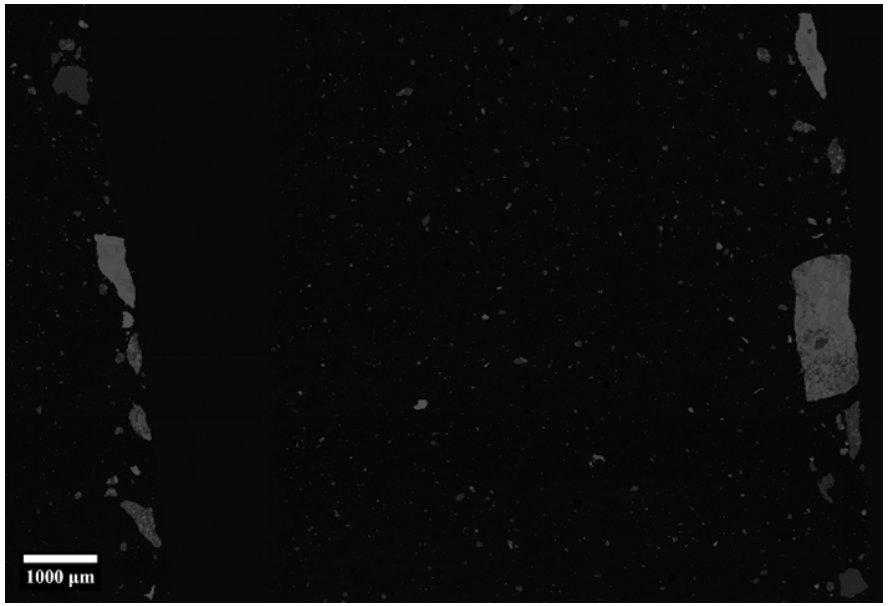
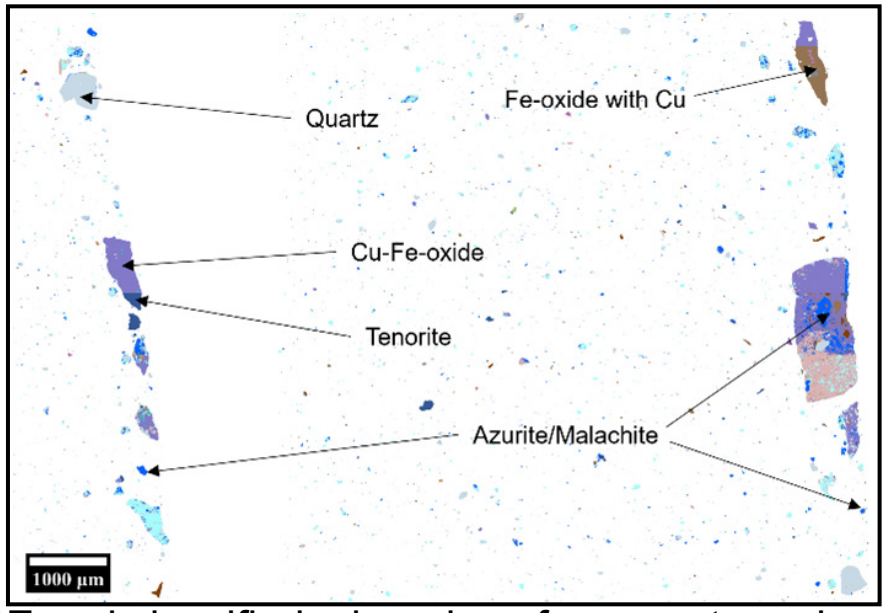
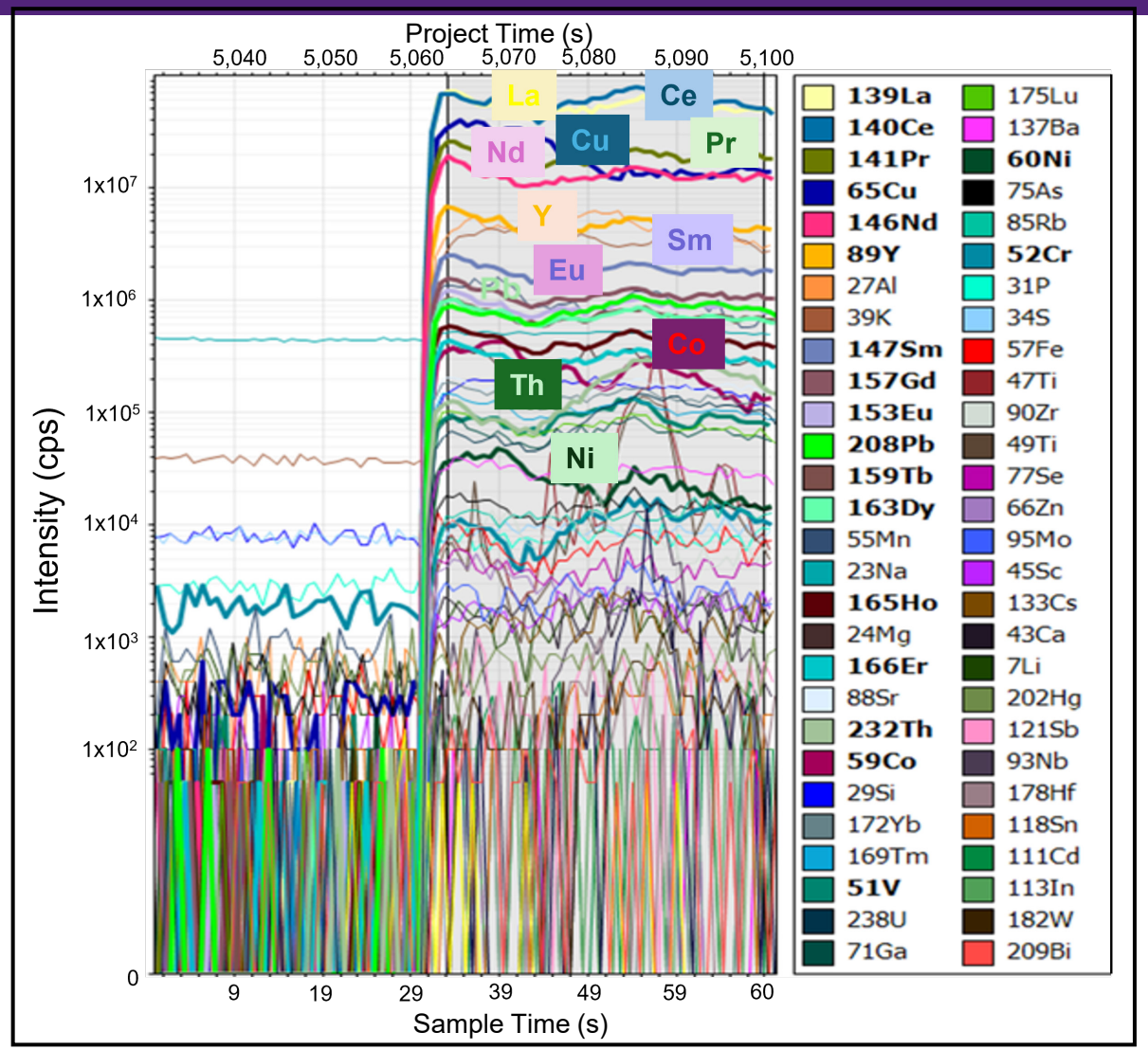
Paratoo- mineral chemistry and REE deportment





BSE and classified mineralogy for a waste rock sample



LA-ICP-MS pattern for a malachite grain

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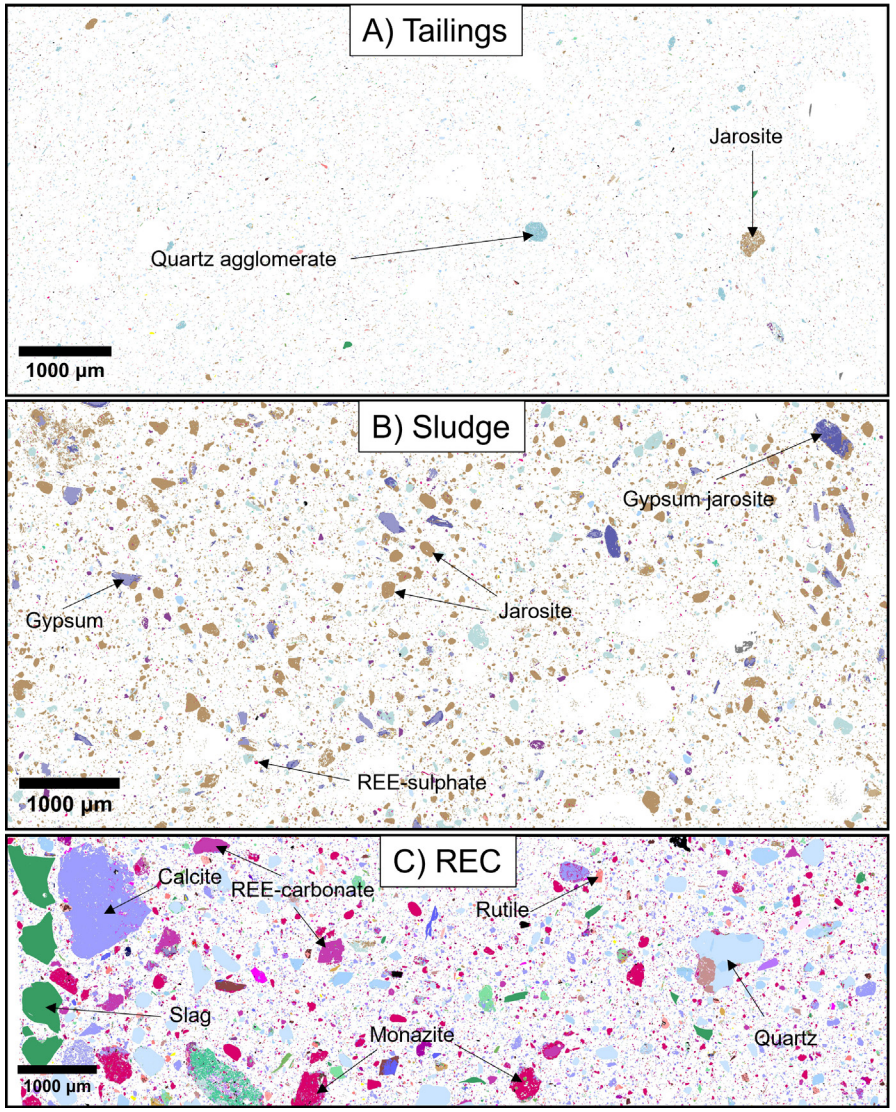
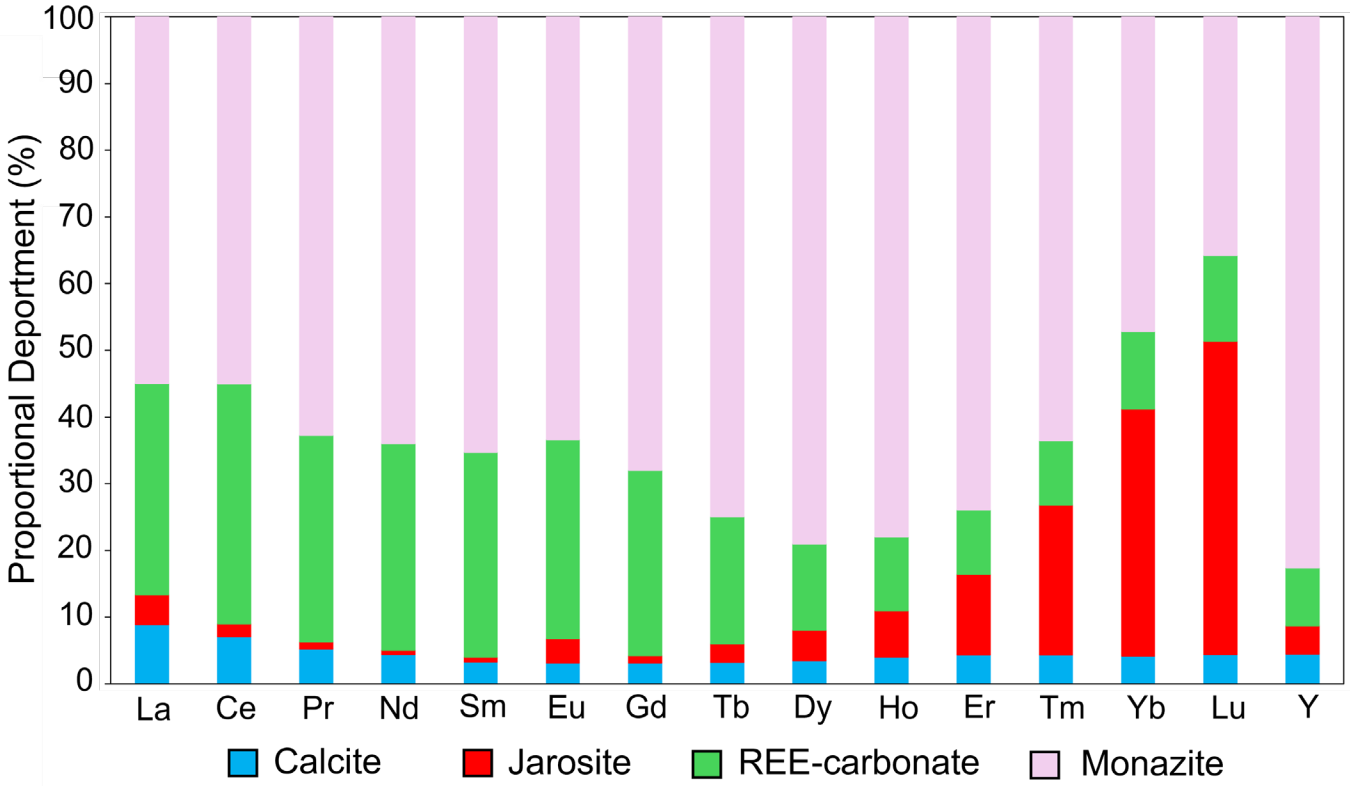
Port Pirie- mineral chemistry and REE deportment



Classified mineralogy images



Stacked bar chart showing the proportional deportment of calcite, jarosite, REE-carbonate and monazite

Prospective sites and metal extraction next steps

Paratoo

- The enrichment in **REE**'s offers a valuable opportunity for integrated recovery
- **Environmentally sustainable recovery options include**:

  - **Bioleaching** – using acidophilic bacteria such as *Acidithiobacillus ferrooxidans,* to enhance Cu recovery where minor sulfides are present
  - **Phytomining** – by cultivating Cu- and potentially REE-hyperaccumulating plants directly on waste dumps
  - **Phytoextraction coupled with electrokinetic recovery** – to mobilise Cu and REE's from fine-grained iron and silicate matrices

Port Pirie

- The Port Pirie mine waste is markedly enriched in **REEs, Pb, U** and **Th**
- **Recovery options include**:

  - **Leaching** – offers a viable method for extracting REEs from carbonate-rich materials, including REE-carbonate phases and associated gangue minerals such as calcite
  - **Biostimulation** – enhances the leachability of target metals

Thank you for your attention!

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Mine Waste Transformation through Characterisation

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https://smi.uq.edu.au/miwatch-mine-waste-transformation-through-characterisation

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