Distinguishing Intrusive Phases in Strongly Altered Hydrothermal Settings:
A CASE HISTORY OF THE APPLICATION OF 4-ACID MULTI-ELEMENT DATA IN A PORPHYRY ENVIRONMENT
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Overview of Northparkes Mines

- Joint venture – CMOC Mining Ltd (80%) and Sumitomo Group (20%)
- 300+ employees
- Copper and gold producer
- Commenced mining in 1994
- First underground block cave mine in Australia
- 1,630 ha of mine lease within 5,670 ha of agricultural land (+ 2,102 ha nearby)
- Current Life of Mine is 2034
Macquarie Arc- Porphyry Cu-Au deposits

Modified from Henry et al. 2014, and Cooke et al., 2007
Northparkes Porphyry Systems

- Late Ordovician to Early Silurian age – 437-439Ma (Lickfold et. al. 2007)
- Silica-saturated Alkalic Porphyry Cu-Au Systems
- Higher grade orebodies have pipe-like geometries
- Hosted by Shoshonitic to High-K Calc-Alkaline volcanic and volcaniclastic package
- Sulphides dominated by Cu-bearing species; bn-cpy+/-cct-tn-cov
- Vein hosted, vein related, and disseminated mineralisation
Northparkes Porphyry Systems

- Discrete ore system footprints: <500m laterally
- Vertically extensive: > 1200m deep
- Disseminated and stockwork mineralisation closely associated with potassic alteration and porphyry intrusions
- 'Classic' zoned sulphide mineralogy with poorly developed distal pyritic halos - bornite cores
Northparkes Porphyries: High Grade Cu/Au

Modified after Sinclair, 2007
Northparkes Porphyries: High Grade Cu/Au

Modified from Lang et al., 1995
Main Deposits

- **E22** and **E27** surface pits – production ceased in 2010
- **E26** Underground – two lifts extracted – potential third
- **E48** Underground – currently extracting from one level
- **GRP314** – Potential Underground
Advances in Exploration Thinking

• Driven by advances in understanding of Alkalic Porphyry systems worldwide – Industry/CODES/MDRU research

• Recognition of ‘wallrock porphyry’ mineralisation:
  − Texturally destructive k-feldspar-albite-sericite alteration assemblages
  − Subtle differences between host rocks and mineralizing intrusions

• Recognition of intact/preserved porphyry systems under cover:
  − with little to no surface geochemical signature
  − associated with cryptic silica-muscovite-albite alteration plumes: ‘grey sericite’
  − Importance of ‘red rock’ alteration as indicator of prospectivity/system fertility

Move away from looking for a direct hit:
Applying trace level multi-element geochemistry

Trachyandesitic volcanic breccia – Hopetoun Prospect
Acquisition of 4-Acid Multi-element Geochemical Data

- 4-Acid digest uses a combination of HCl (hydrochloric acid), HNO3 (nitric acid), HF (hydrofluoric acid) and HClO4 (perchloric acid)
- Because hydrofluoric acid dissolves silicate minerals, these digestions are often referred to as 'near-total digestions'
- Solute analysed by ICP-AES/ICP-MS combination (ALS method ME-MS61)
Acquisition of 4-Acid Multi-Element Geochemical Data

- Extends assay data beyond the obvious...
- Moving into the world of ‘Applied Lithogeochemistry’
- Building comprehensive multi-element database

All samples collected for assay are now analysed by ICP-MS with 4-Acid Digest
Now You’ve Got it… What Next?

• How to use the data to derive value
• Common in industry to acquire data, but still get dragged to the old favourites; Cu, Au, Pb, Zn, As
• Most data sits ‘unloved’ because of a lack of a clear path for how to use it
• 3 main areas for using this data for Applied Lithogeochemistry:
  • Identify Rock Types
    – Sc, Ti, V, Zr, Hf, Nb, Th, La, Ce
  • Quantify Alteration
    – Al, K, Na, Ca, Fe, Mg, Rb, Cs, Sr
  • Pathfinder Patterns
    – As, Sb, W, Mo, Bi, Te, Ti, Ag, Au – value lies in the detection limits!
The Problem:

- Strong alteration at Northparkes commonly obscures or obliterates original rock texture making logging and modelling problematic.
- Texturally destructive alteration both paragenetically early and late, with both phyllic (sericite-quartz) and potassic (k-feldspar-biotite+/-albite-hematite) assemblages.
- Each early to late-syn mineral intrusive phase alters the surrounding rock – compounding the problem!
- Contacts between phases in wallrock hosted systems are gradational and easily missed.

Pre-mineral monzonite clasts in syn-mineral quartz monzonite (R. Lesh)
The Solution: The Phosphorus Story

- Northparkes maintains a strong commitment to research
- Honours thesis examining REE fractionation trends within GRP314 orebody (Johnson, 2011)
- Study showed fractionation of magma chamber at depth (Johnson, 2011) evident in $P_2O_5$ whole rock data
The Solution: The Phosphorus Story

Could this be used to discriminate between phases?

From Johnson, 2011
The Phosphorus Story

- Yes!
- Intrusive units each have distinct P assay signatures, even when partially weathered or intensely altered
The Value in Phosphorus Assays

Exploration
• Potential use in discriminating between fertile systems and ‘red herrings’

Evaluation
• Highly useful in modelling of orebodies for resource/reserve and domaining
• Each intrusive type having different geomechanical properties/gangue mineralogy

Data Validation
• Mis-logged lithologies – validation checks

This unit on validation was mis-logged
P>1000ppm = Not a Zero Porphyry!
Example:
*Which is the mineraliser?*

**Trick Question – There are two!**

- **Pre-Mineral Monzonite**
  - 314-316m: 1000ppm P

- **Mineralising Porphyry**
  - 414-416m: 490ppm P
  - 374-376m: 670ppm P

Hole GD827 – GRP314 Deposit

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Northparkes Mines
A century of mining together
Conclusions

• Most assay data has value – you just have to find out where the value lies!

• 4-Acid near total digest assay data can open up new value opportunities – differentiating intrusive phases is just one
  - Looking beyond the game of ‘Grade or No Grade’

• Multi-element near-total digest geochemistry pays off at Northparkes
  - Both in exploring for new systems, and understanding what you already have