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PhD Project Description

Why are barren porphyry systems unmineralized?

Supervisors

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Research Group

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Project Summary

This project seeks to identify the key process elements that do or do not operate in barren or weakly mineralized porphyry copper systems in comparison to well-mineralized systems. This understanding will allow the development of mineral proxies for the recognition of well-endowed systems that can be used to reduce the risk, energy cost and environmental footprint of porphyry-type ore deposit exploration. The successful student will gain valuable experience of cutting-edge tools for ore deposit exploration, industry applications, fieldwork and analytical methods and will be well placed for a future career in mineral resources research or mineral exploration.

Research Context and Objectives

Porphyry systems represent the world's principal source of copper and molybdenum and are major repositories of gold and silver (Cooke et al., 2014a). These deposits originate from huge volumes of metal-bearing hydrothermal fluid that exsolved from crystallising crustal magma reservoirs. Recent studies have shown that igneous accessory minerals such as zircon and apatite can retain critical chemical information that allows us to distinguish magmas that are predisposed to form porphyry ore deposits (e.g. Loader et al., 2017; Nathwani et al., 2020, 2021). However, we do not really understand processes operating at the deposit level that result in the failure of a mineralizing system to develop, even when the right type of magma is involved. The aim of this project is to identify which part(s) of the porphyry mineral system are the root cause of the failure of economic mineralization to form in altered but barren systems. Possible reasons include: (1) igneous infertility (insufficiently oxidized or hydrous magmas), lack of metals, sulfur or Cl in the source magmas; or (2) potentially fertile magma but ineffective hydrothermal processes, e.g. weak melt-fluid partitioning of ore-forming components, lack of effective sulfide trap mechanism in terms of temperature gradient, pH buffering and/or reductant. We believe that the geochemical signature of minerals in the 'barren system' will, because of one or more of these factors, differ from the equivalent minerals in well-endowed porphyry deposits, allowing for the development of discrimination tools.

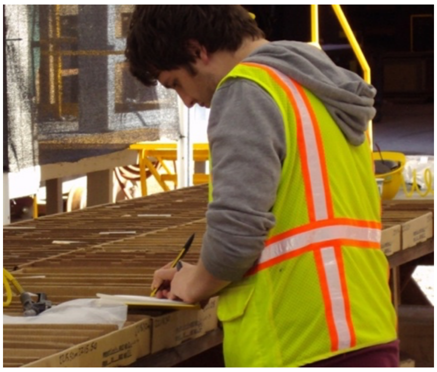

Figure 1: Logging drillcore at the giant Resolution porphyry-Cu deposit, Arizona, USA

Key research questions:

This project aims to answer the following key research questions:

1) What igneous petrogenetic features, physico-chemical properties of fluids, fluid-rock interactions or timescales differ between barren and well-mineralized porphyry centres?

2) Are the fingerprints of these processes preserved in igneous accessory or alteration minerals that allow discrimination of barren and fertile systems?

3) What robust geochemical tools can be developed based on mineral chemistry distinctions (including use of multivariate and machine learning techniques) that could be of practical use in exploration?

4) How can the established porphyry ore genetic model be modified in the light of the research findings?

Engagement and funding support from industry partners is being sought for this project

Further reading:

Cooke, D.R., Hollings, P., Wilkinson, J.J., and Tosdal, R.M. (2014a). 'Geochemistry of porphyry deposits' in Holland, H.D., and Turekian, K.K., eds., Treatise on Geochemistry, 2nd Edition, v. 13, Oxford, Elsevier, pp. 357-381.

Loader, M.A., Wilkinson, J.J., and Armstrong, R.N. (2017). 'The effect of titanite crystallisation on Eu and Ce anomalies in zircon and its implications for the assessment of porphyry Cu deposit fertility', Earth and Planetary Science Letters, 472, pp. 107-119.

Nathwani, C.L., Loader, M.A., Wilkinson, J.J., Buret, Y., Sievwright, R.H. and Hollings, P. (2020). 'Multi-stage arc magma evolution recorded by apatite in volcanic rocks', Geology, 48, DOI: 10.1130/G46998.1

Nathwani, C.L., Simmons, A.T., Large, S.J.E., Wilkinson, J.J., Buret, Y., and Ihlenfeld, C. (2021). 'From long-lived batholith construction to giant porphyry copper deposit formation: petrological and zircon chemical evolution of the Quellaveco District, Southern Peru', Contributions to Mineralogy and Petrology, 176, 12, DOI: 10.1007/s00410-020-01766-1

Wilkinson, J.J., Cooke, D.R., Baker, M.J., Chang, Z., Wilkinson, C.C., Chen, H., Fox, N., Hollings, P., White, N.C., Gemmell, J.B., Loader, M.A., Pacey, A., Sievwright, R.H., Hart, L.A., and Brugge, E.R. (2017). 'Porphyry indicator minerals and their mineral chemistry as vectoring and fertility tools', in McClenaghan, M.B. and Layton-Matthews, D., eds., Application of indicator mineral methods to bedrock and sediments: Geological Survey of Canada, Open File 8345, 2017, pp. 67-77, DOI: 10.4095/306305.

Who are we looking for?

Applicants should have a First Class or good Upper Second Class MSci/MGeol degree or BSc + relevant Masters in geology/geoscience, be a good team player, and have interests in fieldwork, mineralogy, geochemistry, data analytics (including coding) and microanalytical methods, as well as a passion for mineral exploration and ore genesis.

The candidate will have the opportunity to develop their career and profile by presenting at international conferences and publishing in high-impact journals. The project involves interaction with other research groups within and beyond ESE.