Petrologic constraints on the genesis of magmatic-hydrothermal gold-rich ore deposits

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Preface

Gold provinces reflect the presence of a metasomatised underlying subcontinental lithospheric mantle, the efficiency of gold extraction from the mantle source, and the physicochemical properties of the intruding magmas (Loucks, 2012; Hronsky et al., 2012; Tassara et al., 2017, 2020)

The link between metasomatised SCLM and gold provinces

Geodynamic settings that favour metasomatism of the lithospheric mantle

↓ Generation of regions enriched in Au and incompatible elements

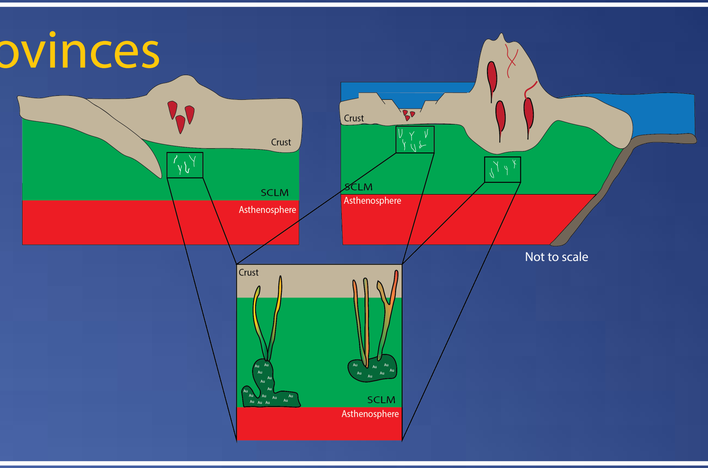
Selective mobilisation of pre-enriched regions of the SCLM

↓ Generation of Au-fertile magmas

Favourable conditions (oxidation state, pressure, hydration state) of the intruding magmas

↓ Exsolution of hydrothermal fluid enriched in Au

Magmatic-hydrothermal Au-rich deposits



Knowledge gaps

- How mantle processes control gold metallogeny
- The behaviour of gold during mantle melting and fractional crystallisation of mantle-derived magmas

Objectives

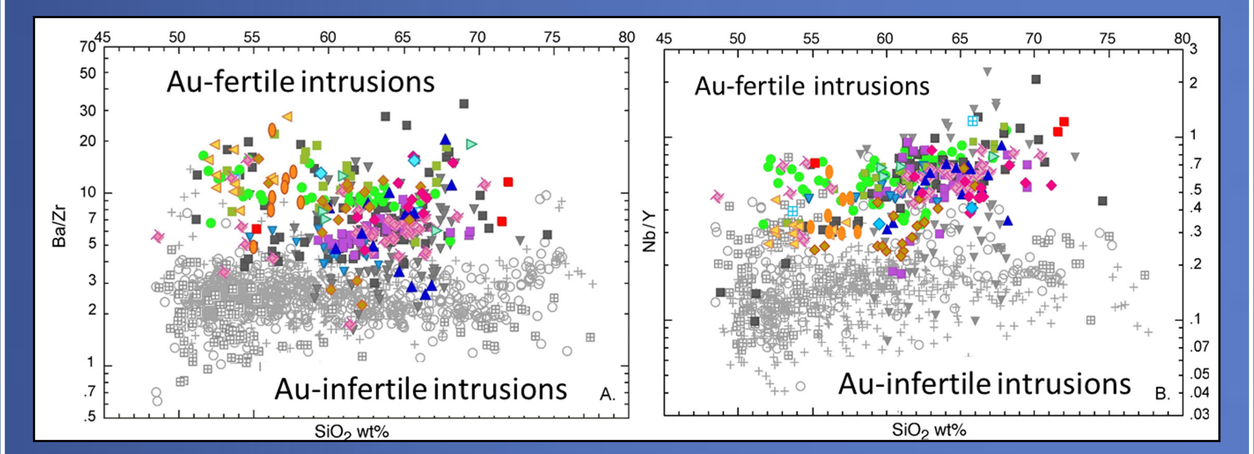
Constrain first-order geochemical controls on gold fertility using whole-rock and accessory mineral geochemistry

1) Identify differences in the mineralogy and chemical composition of the magma source of Au-infertile and Au-fertile sub-alkalic and alkalic gold-rich deposits

2) Use trace element composition of igneous zircon (crystallised from Au-fertile and Au-infertile intrusions) to understand melt evolution

3) Obtain a global perspective on the relationship between the presence of a metasomatised lithospheric mantle and magmatic-hydrothermal gold-rich deposits

Whole-rock fertility indicators

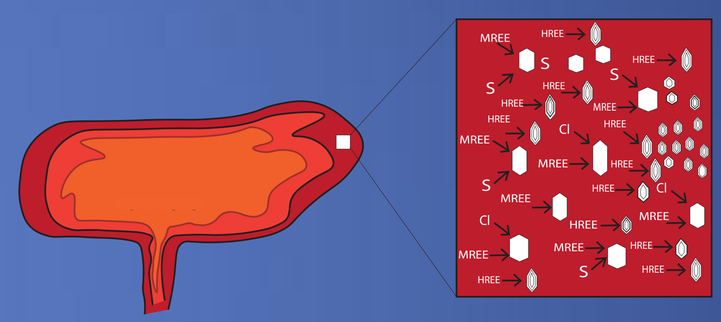


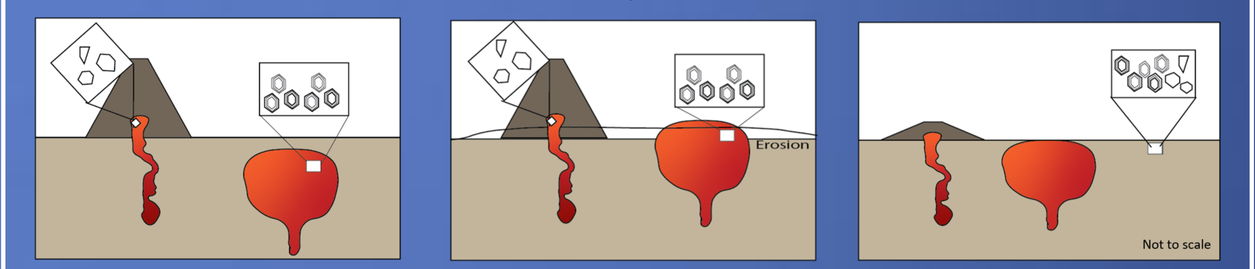
Loucks, pers comm

- Whole-rock signature reflect magmatic evolution of the intruding melt
- Trace element ratios that represent the participation of an enriched source are capable of sorting occurances of Au-fertile intrusions from gold-infertile intrusions throughout the whole mafic-to-felsic spectrum
- Hydrothermal alteration and weathering processes often affect whole-rock composition or remove whole-rock information from geological records (Pizarro et al., 2020)
- Accessory mineral geochemistry can traslate whole-rock information

Accessory mineral geochemistry

- The distinctive chemical features of melts are transmitted to zircon via mineral/melt partition coefficients
- The geochemical signature of zircon can provide powerful petrogenetic information





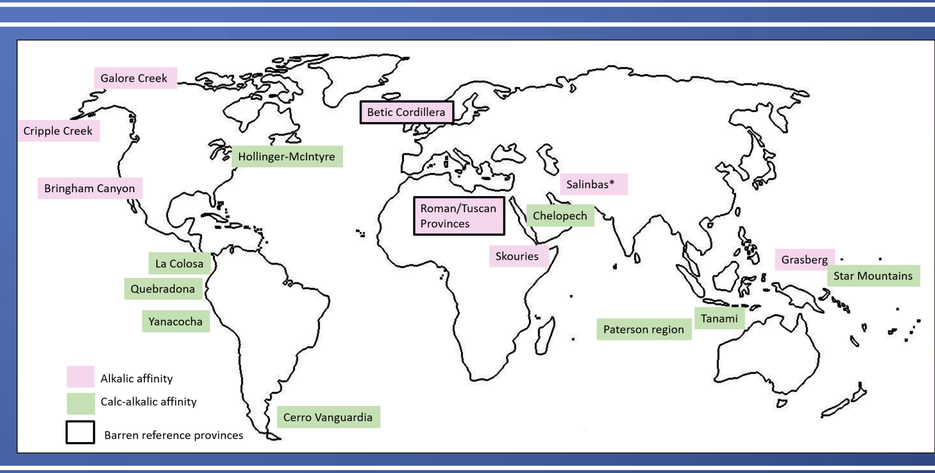
- Zircon survives hydrothermal alteration, weathering, and erosion and can be used to access melt evolution
- Accessory mineral geochemistry is a potential tool for screening terranes with potentially mineralising igneous suites from unprospective ones

Sampling strategy and analytical techniques

To achieve a global perspective, we aim to combine data compiled from the literature with additional samples provided by sponsoring companies and collaborative institutions:

1) Whole-rock chemical analyses of gold-fertile intrusions and barren reference suites of potassic-alkalic rocks along the western Mediterranean

2) Zircon geochemistry (trace-element and radiogenic isotopic geochemistry) from gold-fertile and gold-infertile intrusions



Expected outcomes

1) Identify exploration-relevant chemical characteristics for gold fertility in whole-rock and accessory minerals

2) Determine mantle melting processes that favour the generation of gold-rich melts

3) Understand the petrogenetic meaning of variation in trace element ratios of igneous accessory minerals

4) Empirically calibrate accessory minerals geochemistry as a pathfinder for Au fertility

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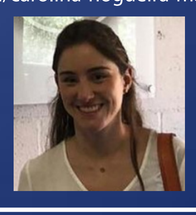

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