A new research line

Magma mixing in porphyry copper deposit formation

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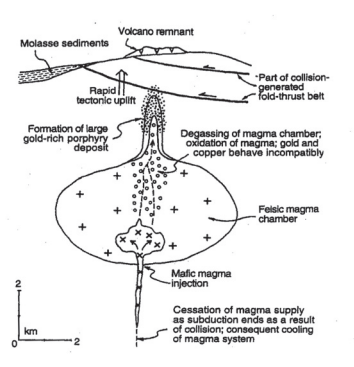
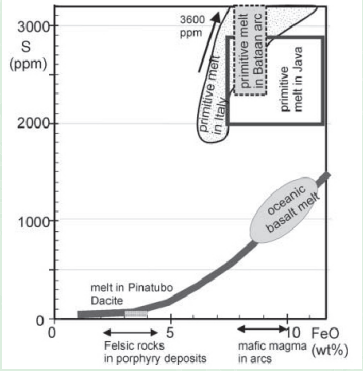
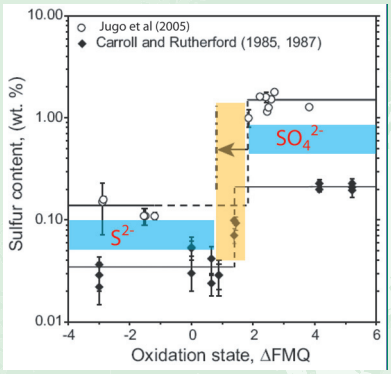
RATIONALE: Magma mixing is common and can provide sufficient sulfur to form a large deposit



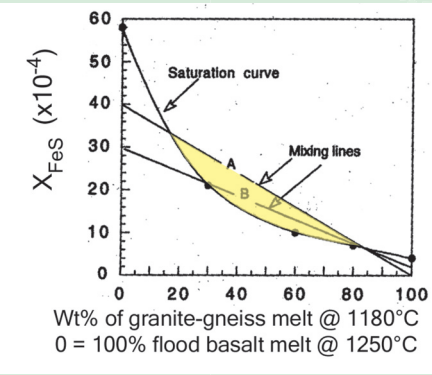
Mafic magma injection is common in (gold-rich) porphyry copper deposit (PCD) forming magmas (Sillitoe, 1997). This has been largely overlooked by workers trying to understand their genesis.



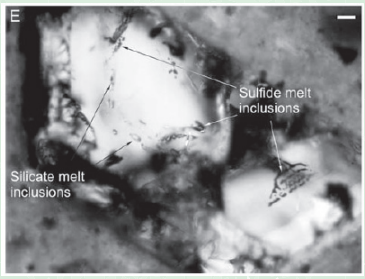
Mafic magma is also a very plausible source of the excess sulfur needed for mass-balancing the amount of sulfides found in PCDs (Hattori and Keith, 2001). Mafic magmas have sulfur solubilities up to 300x those of felsic magmas that we find at PCDs.



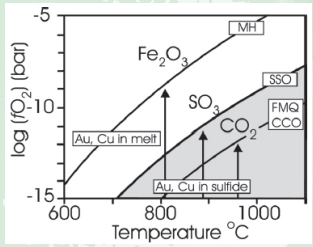
Also, the sulfur content of magmas is strongly dependent on the sulfur oxidation state. This is determined by the redox state of the silicate magma. Oxidised magmas (ΔFMQ>1) can contain ~10x more sulfur.



Under sulfur-saturated and reducing conditions, mixing of mafic and felsic magma results in the exsolution of an immiscible sulfide melt. Furthermore, copper and gold partition very strongly into sulfide melts, relative to silicate melts.



Sulfide melt inclusions are present in PCDs and possibly play an important role in their magmatic evolution (Halter et al., 2005).

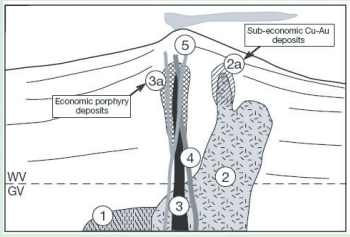


However, only under oxidising conditions are silicate magmas able to carry high concentrations of gold and copper (Mungall, 2002). Furthermore, PCDs are commonly associated with oxidised magmas. So what is the role of these sulfide melts then?
We need to investigate the role of magma mixing and how sulfur behaves in that.

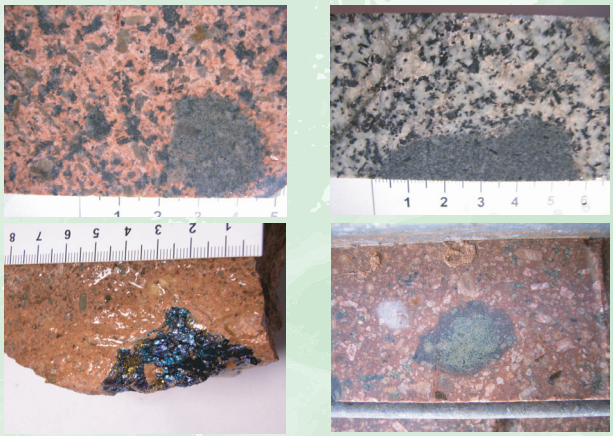
AIMS AND METHODS

I am investigating the role of magma mixing at Northparkes (NSW), and Ok Tedi and Frieda River (Papua New Guinea). Sampling from fieldwork will allow petrographic analysis, trace element phenocryst microprobing and LA-ICP-MS of REE in melt inclusions and PGE in sulfides. In addition, experimental mixing of mafic and felsic magma under different redox conditions is going to provide insight into the role of magma mixing and its effects on the sulfur budget in PCD genesis.

PRELIMINARY RESULTS



The Late Ordovician Northparkes PCD shows a multi-phase intrusive history of monzodioritic to quartz-monzonitic magmas, with a complex, multi-stage hydrothermal overprint. Economic Cu-Au mineralisation is centred on quartz-monzonite porphyries (QMP). Late stage mingled dykes crosscut the main intrusive phases. The geochemistry of the magmatic series is characteristic of a mature oceanic island arc setting.



Indicators for magma mixing at Northparkes (NSW). Upper left and right: Enclaves in variably altered pre-mineralisation monzodiorite. Lower left: Sulfide clots of possible magmatic origin in syn-mineralisation QMP. Lower right: Post-mineralisation basaltic trachyandesite mingled within a mafic monzonite (Lickfold et al, 2002).

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