Geochemistry of Hydrothermal Molybdenite Inclusions: Linking Ore-Stage Pyrite with Accessory Minerals

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Introduction

- Absolute dating is an analytical method which compares relative abundances of isotopic ratios. This isotopic ratio compares parent to daughter elements (^{187}Re to ^{187}Os), and changes over time. Therefore, any parent-daughter ratio records the elapsed time since mineralization
- The Central African Copperbelt (DRC and Zambia) is of tremendous economic importance and the timing of it's copper ores has been debated for decades.
- After the rifting of Rodinia (~700 Ma), the formation of Gondwana (~600-500 Ma) resulted in a 700 Km long mountain range in present day central Africa.
- The origin of copper ores has been attributed to both basin-fill during Rodinia rifting, and a syn-tectonic origin, during the formation of Gondwana.

Methodology

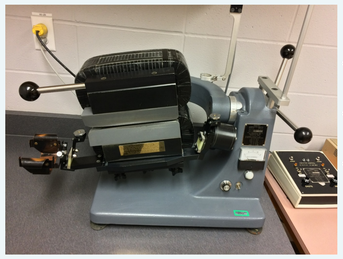

Figure 1

- Physical separation removes the desired mineral from the bulk rock sample
- The rock is crushed to particles ranging from 210 – 74 µm
- Pyrite is extracted from the bulk powder as it is dense and non-magnetic (Figure 1)

- Chemical separation extracts Re and Os isotopes from pyrite
- Sample is spiked and digested in a solution of Aqua Regia
- Isotopic purification is achieved using a distillation technique for Os, and ion exchange chromatography for Re (Figure 2)

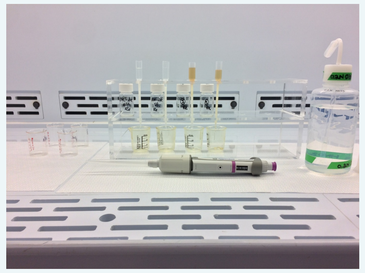

Figure 2

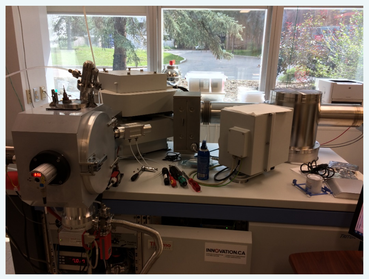

Figure 3

- Purified Re (parent) and Os (daughter) are loaded onto filaments and prepared for analysis
- Precise isotopic measurements are made using a Thermal Ionization Mass Spectrometer (TIMS) (Figure 3)

Methodology Cont.

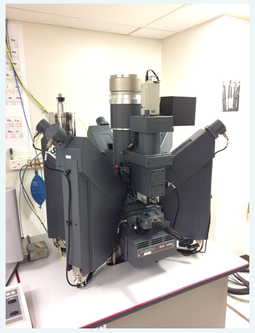

Figure 4

- X-Ray maps are produced from an electron microprobe microanalyzer (EPMA) (Figure 4)
- Element-specific X-Rays are emitted due to atomic-scale energy exchange from sample electrons and incident electron beam
- Very high spatial resolution

Results

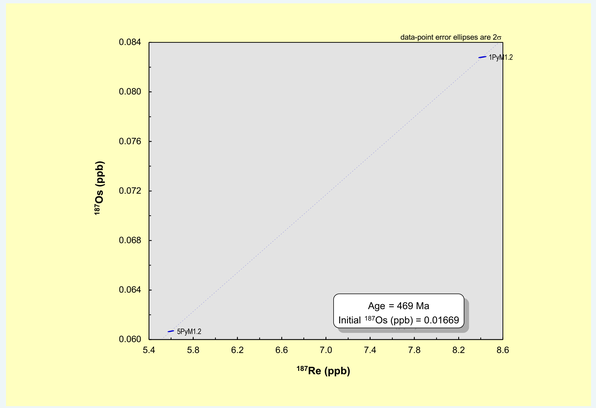

Figure 5

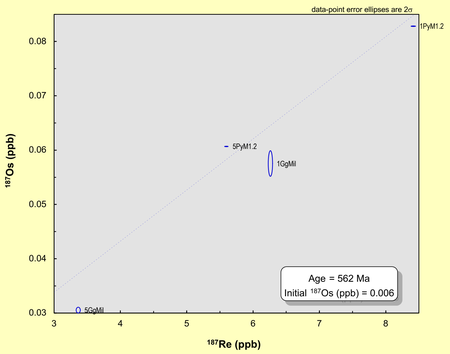

Figure 6

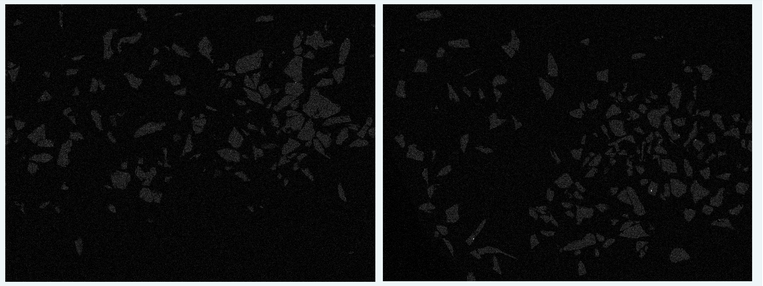

Figure 7 & 8 - *Grayscale X-Ray Molybdenum (Mo) Maps, FOV: 4.096 x 3.072 mm*

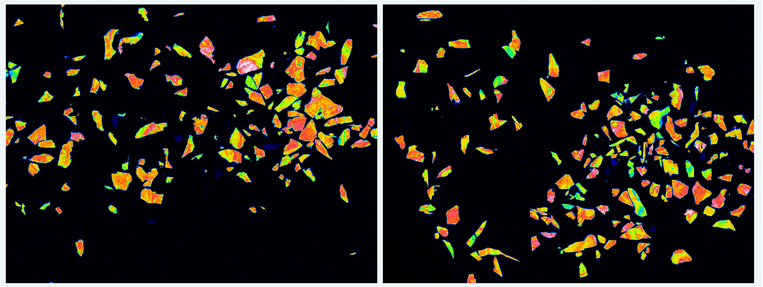

Figure 9 & 10 – Colour enhanced X-Ray Cobalt (Co) Maps, FOV: 4.096 x 3.072 mm, color warmth ∝ higher concentration

Discussion

- Mo X-Ray maps indicate molybdenite inclusions in pyrite (supported by radiogenic nature determined by ^{187}Os/^{188}Os). Molybdenite is the source of rhenium within the sample.
- Co X-Ray maps display intricate zonation. This suggests that the pyrite has not experienced high temperature metamorphism after it crystallized; meaning the Re-Os ages are original.
- Molybdenite inclusions in pyrite yield a regressed age of ~470 Ma (pre-existing age of 537 Ma). This age is the lower bound of ore mineralization
- Molybdenite inclusions in gangue minerals yield a regressed age of 562 Ma (model ages of 542 and 548 Ma), and overlap with aforementioned ages
- These results confirm coeval mineralization of hydrothermal ore with the gangue minerals ca. 537-562 Ma, supporting a Lufilian origin
- Upcoming results from Pb-Pb geochronology will further unravel the timing of these ores

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