Graphite Behavior in Hydrothermal Systems: Examples from the World-Class Mesoproterozoic Merlin Mo-Re Deposit, Queensland, Australia

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Merlin, the world's highest-grade molybdenum-rhenium (Mo-Re) deposit, is primarily hosted by Mesoproterozoic graphitic metasediments belonging to the carbon-rich Kuridala Formation of the Paleo- to Mesoproterozoic Mt. Isa Inlier, NW Queensland. The deposit has a published resource of 6.4 Mt with 1.5% Mo and 18 g/t Re. It is a structurally controlled hydrothermal system lying adjacent to the Mount Dore iron oxide-copper-gold (IOCG) deposit. Molybdenite (MoS_2) and graphite (C) are intimately associated in the ore zones: graphite occurs as fragments within the ore, as well as around the ore margins, where it can form discrete shear zones. Raman microspectroscopy has facilitated the characterization of graphite within the Merlin ore, and provides information on its deportment and genetic implications.

Graphite constitutes up to 10 wt % of Merlin ore, and is lowest (0.01 wt %) in silicified host rock. Raman spectroscopic imaging demonstrates that graphite at Merlin (typically as ~50 × ~500 μm blades) is closely intergrown with molybdenite (200 × 500 μm), and is present along the boundaries of molybdenite grains. Graphite crystallographically ranges from poorly formed in adjacent silicified rock units to well crystallized in the host rock, i.e., carbonaceous slate. Merlin molybdenite has previously been shown to occur in two main forms: "dirty" inclusion-rich anhedral grains (molybdenite 1), and coarser, euhedral, inclusion-free grains (molybdenite 2). The two forms of molybdenite also have differences in trace element composition. Raman imaging further demonstrates that molybdenite 1 and 2 have unique spectral peak shifts, which supports the interpretation that they formed at two separate times under differing physicochemical conditions, and that graphite is mostly present in molybdenite 1 as micron-scale inclusions. Graphite may have provided additional ductility and alternative paths for strain partitioning during ore formation, because in several places mylonitic graphite shears cut the brecciated orebody. The presence of molybdenite and graphite together produced very ductile fabrics. It is still uncertain whether graphite acted as a reductant on ore fluid during initial ore formation or if graphite in stylolites (mainly in originally more carbonate-rich rocks) precipitated from a carbon-saturated fluid rather than being entrained as a residue after dissolution of other minerals from the rock mass.

The working hypothesis is that graphite, originally formed by metamorphism of organic carbon in the Kuridala Formation, was entrained as gouge into brittle faults that formed immediately prior to ore emplacement. As ore fluids utilized these same pathways, in some places with sufficient energy to brecciate the feldspathic alteration halo and lead to further ductile deformation of molybdenite 2, graphite became further mixed with the ore and was overgrown by recrystallized molybdenite, leading to the exceptionally high Mo (and Re) grades locally present in this enigmatic deposit.