Fluid geochemistry of the Archean metamorphosed VMS Cu deposit in the North China Craton

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The Archean greenstone-hosted VMS deposits are the oldest VMS deposits and account for ca. 8% of the global VMS-hosted metal resource. However, Fluid inclusions (FIs) studies on these ancient VMS deposits are still rare, because most of these deposits were remobilized by subsequent metamorphism. The origin of the ore-forming fluids entrapped in the VMS deposits is highly controversial, especially regarding the preservation of primary FIs, sources of metamorphic carbonic fluids (CO_2 or CH_4), and the roles of both primary vent fluids and metamorphic hydrothermal fluid systems in the mineralization.

The Luojiahe Cu deposit is a metamorphosed volcanogenic massive sulfide (VMS) Cu deposit that was located in the southern margin of the North China Craton. The orebodies are hosted in the mafic volcanic-sedimentary sequences of the metamorphosed (greenschist-facies) Neoarchean Songjiashan Group. The Luojiahe Cu mineralization can be divided into the primary VMS mineralization stage (Stage I, banded or stockwork ores) and the subsequent metamorphic remobilization stage (Stage II, coarse-vein ores). Based on detailed petrographic observation, we found that some quartz (Q1) from the banded ores (Stage I) remained unstrained because they are inside the sulfides. Primary FIs were observed in Q1, which provides new insight into the understanding of the original submarine hydrothermal processes on the Archean VMS deposits. Systematical FIs and C-H-O isotope analyses were carried out on Q1, stockwork ores (Stage I) and coarse-vein ores (Stage II).

We propose that at Stage I, the main mineralization may have been resulted from 1) fluid mixing of hot evolved seawater and cold seawater in the near-surface environment; and 2) fluid unmixing caused by the percolation of magmatic fluids into syn-volcanic faults, forming the stockwork ores. At Stage II, the interaction between H_2O and graphite may have resulted in the reduction of ore-forming fluids and Cu precipitation, and fluid unmixing in the CH_4-NaCl-H_2O system may have further promoted the Cu mineralization.