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The Archean Cu-Zn Magnetite-Rich Gossan Hill Volcanic-Hosted Massive Sulfide Deposit, Western Australia: Genesis of a Multistage Hydrothermal System

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Abstract

The Gossan Hill volcanic-hosted massive sulfide (VHMS) deposit is an Archean Cu-Zn-magnetite–rich deposit located in the Warriedar fold belt of the Yilgarn craton, Western Australia. The deposit is hosted by redeposited rhyodacitic tuffaceous volcaniclastics of the Golden Grove Formation and is overlain by felsic volcanic rocks of the Scuddles Formation. The deposit consists of two separate subvertical ore zones. The stratigraphically lower Cu-rich ore zone (7.0 Mt @ 3.4% Cu) is strata bound and varies from podiform massive pyrite-chalcopyrite-pyrrhotite-magnetite to sheetlike massive magnetite-carbonate-chlorite-talc. The upper Zn-Cu ore zone (2.2 Mt @ 11.3% Zn, 0.3% Cu, 1.5 g/t Au, and 102 g/t Ag) contains strata-bound massive sphalerite-pyrite-chalcopyrite that overlies discordant, moundlike massive pyrite-pyrrhotite-chalcopyrite-magnetite. Sulfide stockwork connects the upper and lower ore zones. Metal zonation varies from Cu (± Au) in the lower ore zone to Zn-Cu at the base of the upper ore zone, which grades upward and laterally to Zn-Ag-Au (± Cu, ± Pb). Multiphase deformation and greenschist facies metamorphism overprint the deposit.

The relationship between host rocks and sulfide indicates that mineralization was broadly codepositional with sedimentation of the Golden Grove Formation. However, gradational and interdigitating contacts between these volcaniclastic rocks and magnetite support the formation of massive magnetite by subsea-floor replacement. Sulfides replace and vein the massive magnetite with inferred synchronous formation of the upper and lower sulfide ore zones. Although these sulfide ore zones formed mainly by subsea-floor replacement, stratiform hydrothermal chert-sulfide-sediment layers within, and adjacent to, the upper Zn-rich ore zone attest to some local exhalation.

The thickest development of massive magnetite, massive sulfide, and stringer stockwork occurs in the north of the deposit and supports a common feeder during massive magnetite and sulfide formation. Furthermore, local chlorite-quartz hydrothermal alteration, massive magnetite, massive sulfide, and stockwork all form asymmetric zones that thin southward. These attributes indicate strong synvolcanic structural control during mineralization; the relict synvolcanic growth structure is obscured and probably occupied and by a dacite dome of the hanging-wall Scuddles Formation. Thermodynamic considerations suggest that massive magnetite and sulfide formed from similar high-temperature (>300°C), slightly acidic, low-f_{O_2} hydrothermal fluids. Massive magnetite formed from H_2S-poor fluids, whereas massive sulfide formed from relatively rich H_2S fluids. Physicochemical changes associated with interaction between upwelling, H_2S-bearing fluids and preexisting massive magnetite may have resulted in the subsea-floor precipitation of sulfide in the lower Cu-rich ore zone.

The Gossan Hill VHMS deposit represents a multistage hydrothermal system within an environment characterized by rapid volcaniclastic sedimentation and changing structural and magmatic processes. The six main stages were as follows: (1) initiation of the hydrothermal system, (2) sedimentation, metasomatism, and progressive heating of convecting fluids, (3) deposition of massive magnetite from H_2S-poor fluids by subsea-floor replacement above a buried synvolcanic conduit, (4) structural reactivation tapping deeper H_2S- and metal-bearing fluids, (5) subsea-floor replacement and minor exhalative sulfide mineralization, with (6) burial and preservation of the deposit resulting from proximal felsic volcanism.