

# Alteration Characteristics of the Archean Golden Grove Formation at the Gossan Hill Deposit, Western Australia: Induration as a Focusing Mechanism for Mineralizing Hydrothermal Fluids

ROBINA SHARPE† AND J. BRUCE GEMMELL

*Center for Ore Deposit Research, University of Tasmania, GPO Box 252-79, Hobart, Tasmania, Australia 7001*

## Abstract

The Archean Golden Grove Formation is a 550-m-thick rhyodacitic tuffaceous volcanoclastic succession that hosts the Cu-Zn-rich Gossan Hill volcanic-hosted massive sulfide (VHMS) deposit in the Yilgarn craton, Western Australia. The Golden Grove Formation consists of volcanic quartz and altered pumice and shards, which were deposited during successive episodes of subaqueous mass flow. Coherent volcanics are absent from the Golden Grove Formation at Gossan Hill but form the main rock type in the hanging-wall Scuddles Formation. A massive dacite dome that overlies its volcanic feeder dike is inferred to occupy a synvolcanic structure that focused mineralizing fluids during the formation of the Gossan Hill deposit.

The Gossan Hill deposit consists of two stratigraphically separate ore zones interconnected by stockwork. The Cu-rich lower ore zone and the Zn-rich upper ore zone occur in the middle and upper parts of the Golden Grove Formation, respectively. Podiform zones of massive magnetite occur in the Cu-rich ore zone, where the formation of magnetite predates massive sulfide. The asymmetry of massive sulfide, massive magnetite, and alteration zones at the Gossan Hill deposit attest to synvolcanic structural control during mineralization.

The principal lithofacies of the Golden Grove Formation are sandstone and pebble breccia, which have a regionally extensive quartz, Fe-rich chlorite, and lesser muscovite alteration. At Gossan Hill, this alteration has resulted in near-complete replacement of tuffaceous components, causing substantial chemical modification of the primary lithologies. Quartz-chlorite ( $\pm$ muscovite) alteration is characterized by severe  $K_2O$ ,  $Na_2O$ , and  $CaO$  depletion, with rocks consisting principally of  $SiO_2$ ,  $FeO$ ,  $Al_2O_3$ , and  $MgO$ , along a quartz-chlorite mixing trend. Widespread preservation of pumice and shard volcanic textures within the Golden Grove Formation indicates that quartz-chlorite ( $\pm$ muscovite) alteration occurred soon after, or possibly during, sedimentation. The absence of diagenetic compaction textures further suggests induration of the succession during this early alteration stage, with the tuffaceous succession largely sealed from the texturally destructive effects of subsequent hydrothermal alteration, except where mineralizing fluids were locally channeled along synvolcanic feeder conduits.

Local intense hydrothermal alteration zones surround the Gossan Hill deposit and overprint earlier quartz-chlorite ( $\pm$ muscovite) alteration. These local alteration zones have the same extent as the sulfide vein envelope and represent hydrothermal alteration formed during sulfide-magnetite mineralization. Intense Fe-rich chlorite (ankerite-siderite) alteration occurs as a strata-bound envelope around massive magnetite, Cu-rich veins, and massive sulfide in the lower ore zone. This chlorite-rich alteration has strong  $FeO$  and  $MgO$  enrichment with minor chloritoid and andalusite that reflect intense acid leaching during hydrothermal alteration.

Iron chlorite (ankerite-siderite) alteration grades upward into discordant to strata-bound intense quartz alteration. Intense quartz alteration forms an envelope around Zn-rich veins and massive sulfide in the stockwork and upper ore zone. The trend from Fe chlorite-ankerite-siderite to quartz alteration toward the top of the deposit is consistent with the cooling of hydrothermal mineralizing fluids nearing the sea floor. Rhyodacite and dacite volcanics of the hanging-wall Scuddles Formation have a pervasive muscovite-calcite alteration. Muscovite-calcite alteration led to  $Na_2O$  depletion and  $CaO$  and  $K_2O$  enrichment associated with burial of the Gossan Hill mineralizing system.

We propose that the Gossan Hill sulfide-magnetite VHMS deposit formed during an evolving Archean hydrothermal system that began as part of a regional-scale, low-temperature seawater convection-alteration system. Initially, this system caused extensive replacement of the Golden Grove Formation by quartz and Fe chlorite ( $\pm$ muscovite); a process that sealed and indurated the volcanoclastic rocks by infilling of primary porosity and permeability structures. Due to subsequent impermeability of the host-rock succession, later and hotter mineralizing fluids that generated alteration and massive magnetite and sulfide at the Gossan Hill deposit were constrained to, and focused upward along, a synvolcanic feeder structure.