

## Volcanic Influences on Hydrothermal and Diagenetic Alteration: Evidence from Highway-Reward, Mount Windsor Subprovince, Australia

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### Abstract

Synvolcanic sills and cryptodomes hosting the Highway-Reward volcanic-hosted massive sulfide deposit invaded wet, poorly consolidated silt, sand, and pumice breccia. Margins of the porphyritic units display perlitic and quench fractures suggesting that they were formerly glassy. Interiors of the rhyolites, rhyodacites, and dacites were originally glassy, partly glassy, or comprised crystalline domains exhibiting spherulitic, lithophysae, and micropoikilitic textures. No glass is preserved and the sills and cryptodomes are now completely crystalline. Primary devitrification structures crystallized early above the glass transition temperature and before the formation of perlite or quench fractures. Crystallization of residual glass proceeded by diagenetic alteration, volcanic-associated hydrothermal alteration, and ore-associated hydrothermal alteration.

Massive sulfide ore is enclosed in a discordant alteration envelope that extends at least 60 m above ore and is known to a depth of 150 m in the footwall. In general, there is a progression from central quartz-sericite  $\pm$  pyrite zones, giving way to zones of chlorite  $\pm$  anhydrite  $\pm$  gypsum, chlorite-sericite-quartz, and finally chlorite-sericite distal to ore. The outermost alteration grades into lithofacies that have altered to various background assemblages of feldspar, hematite, sericite, chlorite, quartz, epidote, and carbonate.

Compared to least altered lithofacies, the quartz-sericite  $\pm$  pyrite zones are enriched in SiO<sub>2</sub>, K<sub>2</sub>O, Fe<sub>2</sub>O<sub>3</sub>, S, and Ba, and depleted in Na<sub>2</sub>O, CaO, MgO, and Sr. Elevated concentrations of MgO, Fe<sub>2</sub>O<sub>3</sub>, and S, coupled with low Na<sub>2</sub>O, CaO, and K<sub>2</sub>O values, characterize chloritized zones. The pattern of low Na<sub>2</sub>O, CaO, and MgO values and high K<sub>2</sub>O values passing outward through the chlorite-sericite  $\pm$  quartz zones is more erratic. The Ishikawa alteration index (AI) value and the chlorite-carbonate-pyrite index (CCPI) value become progressively larger passing from background-altered facies (AI <60; CCPI = 20–55) into the footwall and hanging-wall alteration zones (AI = 89–97; CCPI = 41–99). At AI values greater than 90, Cu, Bi, and Mo are elevated. The S/Na<sub>2</sub>O ratio increases toward ore, whereas Sr/Ba ratios are lowest at AI values above 90. The geochemical halo patterns reflect the composite response of lithofacies to mineralogical and textural changes accompanying diagenetic alteration, volcanic-associated hydrothermal alteration, and ore-associated hydrothermal alteration.

Most alteration zones around ore display two or more overprinting alteration mineral assemblages. Within single alteration zones, the distribution of alteration minerals and assemblages varies spatially in response to contrasting lithofacies character. Formerly glassy coherent and volcanoclastic facies display mineralogical and textural changes that reflect the influence of fracture (perlitic, quench) and/or matrix permeability and porosity on fluid migration. Crystalline domains of volcanic facies generally preserve their original texture, although recrystallization has partly destroyed primary devitrification microstructures. Alteration minerals are localized along cooling joints, hydraulic fractures, and veins or form mottled, patchy, or wispy domains. In contrast, siltstone that separates intrusions and forms the matrix in peperite is relatively unaltered or was baked during magma-sediment mixing.

In zones of intense quartz-sericite  $\pm$  pyrite, chlorite  $\pm$  anhydrite  $\pm$  gypsum, and sericite alteration, high water/rock ratios, an extended history of fluid flow, and elevated temperatures promoted large-scale mobilization of elements in all facies. Relics of the early alteration mineral assemblages are locally preserved in these zones and imply a progression from initial volcanic-determined alteration to hydraulic fracture and vein-controlled alteration as the hydrothermal system intensified.

The distribution of alteration assemblages and ores implies that fluid pathways varied in scale from very large, where the sills and cryptodomes focused hydrothermal fluid flow and mineralization, to very small where volcanic fracture-controlled porosity and permeability localized mineral precipitation.