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The Subsea-Floor Replacement Origin of the Ordovician Highway-Reward Volcanic-Associated Massive Sulfide Deposit, Mount Windsor Subprovince, Australia

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Abstract

The Highway-Reward massive sulfide deposit is hosted by a submarine (below storm-wave base), silicic, synsedimentary intrusion-dominated volcanic succession. The succession includes at least 13 porphyritic units in a volume of 1 x 1 x 0.5 km. Peperitic upper margins suggest that most of the rhyolites, rhyodacites, and dacites were emplaced as small (<350 m diam) synsedimentary sills and cryptodomes. The intrusions are separated by thin (0.2ñ30 m) disrupted intervals of siltstone, sandstone, nonwelded pumice breccia, and polymictic lithic breccia. Evidence for eruption of magma onto the sea floor is limited to a single, partly extrusive cryptodome.

The Highway and Reward pyrite-chalcopyrite pipes occur within, but close to, the margins of the intrusions. The pipes are discordant to local bedding and contain relic patches of rhyolite, rhyodacite, and peperite. Pyrite ± quartz stringer veins extend beneath the massive sulfide pipes, and in some sections also occur in strongly altered strata above the pipes. The pyrite-chalcopyrite pipes are enveloped by a halo of pyrite-sphalerite ± chalcopyrite ± galena ± barite ore, which includes a small strata-bound lens. Near-surface pyritic ores have oxidized to form gossanous zones.

Massive sulfide ores are enclosed within a discordant hydrothermal alteration envelope that extends at least 150 m below the orebodies to over 60 m above the Highway pipe. The envelope exhibits a mineralogical zonation, with central quartz-sericite ± pyrite zones surrounded by zones of chlorite ± anhydrite ± gypsum, chlorite-sericite-quartz, and lastly, chlorite-sericite at the margins. Outside the hydrothermal alteration envelope, felsic volcanic rocks have altered to various assemblages of feldspar, sericite, chlorite, epidote, calcite, quartz, and hematite.

Overprinting relationships and isotopic values are consistent with syngenetic accumulation of the massive sulfides. Most of the ores formed by subsea-floor replacement of rhyolite, rhyodacite, and volcaniclastic units because: (1) massive sulfide ores are enclosed within intrusive or mass-flow emplaced units; (2) discordant and strata-bound ores contain relics of coherent facies or precursor volcanic particles; (3) peperite and massive sulfides are not mixed, implying ore deposition postdated emplacement of the enclosing succession; (4) pyrite pipes are discordant to local bedding; (5) there are replacement fronts passing from discordant pyrite pipes into a strata-bound sphalerite-rich lens; and (6) zones of strong hydrothermal alteration and veining extend into the hanging wall without any abrupt breaks in intensity.

At the Highway-Reward deposit, deformation, disruption of bedding, resedimentation, and induration of the host succession accompanied emplacement of sills and cryptodomes. The resultant variations in secondary permeability and porosity are interpreted to have focused ascending hydrothermal fluids within the fractured glassy margins of synsedimentary intrusions. Pyrite-chalcopyrite pipes formed from relatively oxidized, mildly acidic (pH 4.5-5.0), high-temperature (>300°C), H_2S-dominant fluids by replacement of rhyolite, rhyodacite, and peperite. Lower temperature (<300°C) fluids that diffused from the margins of the pipes deposited a halo of sphalerite-rich ore.