

Quantitative Ore Mineralogy and Variations in Vein Textures in the World-Class Waihi Epithermal Au-Ag District, New Zealand

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The Waihi district in the Hauraki Goldfield of New Zealand contains a series of adularia-sericite epithermal Au-Ag veins that has produced more than 6.8 Moz Au. We used reflected light microscopy, scanning electron microscopy, microprobe analyses, laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS), and automated mineralogy (QEMSCAN) to analyze ore mineralogy. We used hand sample examination, transmitted light microscopy, scanning electron microscopy, and scanning electron microscopy-cathodoluminescence (SEM-CL) to describe and characterize quartz textures in veins. Critical comparison of opaque minerals and quartz textures within eight major veins of the Waihi district shows significant mineralogical and textural variations among veins.

The peripheral veins of the district (Martha, Favona, Moonlight, Cowshed, and Silverton) contain abundant colloform, cherty, and black quartz fill textures, with minor crustiform and massive quartz. The central veins (Amaranth, Trio, and Union) contain predominantly massive and crustiform textures, and these veins are also commonly coarser grained than peripheral veins. Most of the textures identified with SEM-CL correlate with textures that are visible in hand sample and under the microscope, and are well described in the epithermal literature, such as colloform bands, comb quartz, and moss texture. However, some textures are visible only with SEM-CL and have not been previously recognized. These textures include microbreccias and other discontinuities that crosscut mineral growth and vein bands, suggesting that microscale fracture permeability may be more common and important in epithermal deposits than previously recognized.

Pyrite, sphalerite, galena, chalcopyrite, electrum, and acanthite occur in both peripheral and central veins; base metal sulfide minerals typically increase in abundance in deeper samples. Less abundant ore minerals include tetrahedrite, aguilarite, naumannite, uytendogaardtite, stephanite, pyrargyrite, polybasite, pearceite, mckinstryite, stromeyerite, and hessite. The distribution and abundance of these minerals varies within and among veins. Aguilarite, naumannite, mckinstryite, and stromeyerite are confined to the Favona deposit, whereas tetrahedrite is most abundant in the Favona and Moonlight veins. Stephanite, pyrargyrite, pearceite, polybasite, and tetrahedrite occur at shallow depths in the Moonlight vein, whereas acanthite is abundant at similar depths in the Martha and Welcome veins. Electrum is by far the most widespread, abundant, and significant Au-bearing mineral. Limited LA-ICP-MS analyses show that Au also occurs in arsenian pyrite, and QEMSCAN analyses have detected rare Au-bearing telluride and selenide minerals.

Vein textures and ore mineralogy changes are consistent with formation of the central veins at a deeper structural level than peripheral veins. Mineralogical variations produce changes in the concentrations of Se, As, and Sb in the ores that have important metallurgical

and environmental implications. Gold- and Ag-bearing ore minerals occur only in certain, typically finer grained bands of veins, requiring episodic precipitation of those minerals, and suggesting episodic influx of Au- and Ag-rich magmatic-hydrothermal fluids. Available fluid inclusion homogenization temperatures (Martha: 145°–295°C; Union: 150°–300°C; Favona: 165°–274°C) do not suggest large temperature variations among the different veins, and, therefore, the variability in the Se, As, and Sb contents of the ore assemblages presumably reflects episodic variations in the chemistry of hydrothermal fluids from place to place, and perhaps through time.