# THE STRUCTURAL AND HYDROTHERMAL EVOLUTION OF INTRUSION-RELATED GOLD MINERALISATION AT THE BREWERY CREEK MINE, YUKON, CANADA.

Thesis submitted by

**Mark J. Lindsay B.Sc. (Hons.), MAIG**

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for the degree of Doctor of Philosophy (geology) in the School of Earth Sciences at James Cook University of North Queensland.

I dedicate this thesis to my grandmother, Eva Marie Weeks.

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# Abstract

Vein, fracture and disseminated Au-As-Sb mineralisation at Brewery Creek is principally hosted by Tombstone Plutonic Suite (TPS) monzonite sills that have intruded Palaeozoic sedimentary and volcanic rocks of the Selwyn Basin and the Earn Group. The overall architecture of the property is that of a broad NNE trending arch of thrust sheets, with the rocks in each thrust sheet deformed into upright to steeply inclined, open to tight, variably NE, E, NW trending and plunging folds. Middle Cretaceous intrusive rocks including monzonite, syenite and hornblende gabbro cut the thrust faults and folds. The monzonite intrusive rocks crop out through the centre of the Brewery Creek property as a series of elongate, E oriented sills that have been subsequently deformed by numerous, variably oriented normal faults

The paragenetic history of Brewery Creek can be resolved into three main stages: pre-, syn- and post- TPS intrusion. The pre-TPS intrusion stage encompasses sedimentary rock hosted disseminated and massive pyrite, carbonate veins and breccia infill, quartz veins, and stylolites. The TPS intrusion stage comprises the emplacement of TPS intrusions and the development of their contact aureoles and the post-TPS intrusion includes pyrite ± quartz ± carbonate ± roscoelite veins, quartz only veins, gold bearing arsenopyrite-quartz-carbonate veins, several stages of brecciation and stibnite ± quartz ± carbonate ± kaolinite veins.

Gold assay analysis and vein measurements from the open pits along the Reserve Trend highlight two distinct mineralised orientations, E and NE. These orientations are paralleled by numerous metre-scale, steeply dipping post-TPS faults and mineralisation is bound at depth by a moderately dipping, E-striking normal fault, termed the Basal Fault. The observed normal displacement, which is evident on all of the post-TPS faults, combined with steeply dipping E-trending gold bearing veins is best explained by mineralisation occurring during a period of local extension.

Gold mineralisation at Brewery Creek is characterised by an Au-As-Sb ± Ag, Pb geochemical signature with elevated As (> 1000 ppm) being the best indicator of Au > 1 ppm. High concentrations of Sb in intrusive rocks and elevated levels of Ag and Sb in sedimentary rocks provide further indication of Au. Alteration is characterised by enrichment of $CO_2$, $K_2O$, MnO, and $SO_3$ and depletion of $Na_2O$. This element mobility can be directly correlated to pervasive carbonate, pyrite and arsenopyrite alteration of

feldspar and biotite in monzonite sills. CaO and $Fe_2O_3$ are comparatively immobile, which suggests that the Ca and Fe required to form calcite and pyrite respectively was sourced from destruction of feldspars and biotite.

The highest Au concentrations at Brewery Creek are hosted by arsenopyrite crystals with lower but significant levels of Au also found in arsenopyrite overgrowths on pyrite and pyrite overgrown by arsenopyrite. Gold is preferentially distributed into arsenopyrite and pyrite phases hosted by carbonate and clay altered wall rock. Vein-hosted sulphide minerals are volumetrically minor and contain lower concentrations of gold.

Hydrothermal fluids associated with mineralisation were reduced, $CO_2$ rich and near neutral in pH. Gold was likely to have been transported as a bisulphide complex and the predominance of Au-bearing wall rock arsenopyrite and arsenian pyrite emphasise the importance of sulphidation reactions as a Au precipitation mechanism.

Isotope data provide evidence for significant input of magmatic fluids into the mineralising system at Brewery Creek. The calculated fluid compositions are consistent with an initial mixed magmatic and crustal (sedimentary) source that is replaced over time by a mixed magmatic and evolved meteoric fluid source. A genetic model for mineralisation is described that is based on emplacement of felsic magma and subsequent cooling of the associated hydrothermal system.

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