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The nature and origin of the Brucejack high-grade epithermal gold deposit, British Columbia, Canada

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A major challenge in understanding the genesis of epithermal gold deposits is that existing models do not satisfactorily explain the mechanisms responsible for high-grade gold deposition at temperatures characteristic of the epithermal realm (150–300°C). Although transport by dissolution in an aqueous hydrothermal liquid is the widely proposed mechanism for mobilizing gold within Earth's upper crust, experiments have shown that the solubility of gold is too low in hydrothermal liquids at temperatures of < 400°C to account for the extraordinarily high grades observed in some epithermal deposits. Resolving the issue of how exceptionally high grade epithermal gold deposits form will be an important step in elucidating the broader question of how these deposits truly relate to the higher temperature Cu–Mo±Au porphyry systems with which they are commonly associated.

The Brucejack deposit, currently undergoing preproduction mine development in northwestern British Columbia, is host to one of the highest grade epithermal gold deposits in the world (up to 41,582 g/t Au over 0.5 m diamond drill core intervals). The well-explored nature of epithermal gold mineralization on the Brucejack property, combined with its proximity to well-explored, world-class Cu-gold-Mo porphyry deposits (Snowfield and Kerr-Sulphurets-Mitchell) of the Stikine Arc, offer an unparalleled opportunity to study the genesis of epithermal gold deposits, investigate their hydrothermal evolution and, importantly, test their relationship to spatially associated porphyry systems.

Results from our investigations of mineralized quartz-electrum±carbonate veins from the Valley of the Kings (VOK) zone at Brucejack indicate that the deposit formed from a hydrothermal system with a complex history of multiple, possibly long-lived mineralizing events. The formation of five syn-mineral vein stages and sub-stages appears to have resulted from multiple pulses of fluid that circulated through the deposit under dynamic physicochemical conditions, including fluid-overpressure and silica-dissolution events. Preliminary transmission electron microscopic (TEM) imaging has revealed the presence of ~ < 1 to 10 nm wide spherical nano-crystals of electrum within these veins, suggesting that boiling-mediated nanoparticle suspensions (colloids) may have played a role in greatly increasing the capacity of the ore-forming fluid to carry gold by allowing for physical transport. Analyses of pre-electrum pyrite using EMP-WDS and LA-ICP-MS methods show that arsenic-rich growth zones contain up to 1920 ppm gold, indicating that auriferous pyrite mineralization, likely related to a phyllic alteration of the volcano-sedimentary country rocks surrounding older neighboring porphyry deposits, is also partially responsible for the 8.6 million ounce gold reserve at Brucejack.

We are progressing towards the development of a detailed genetic model for Brucejack by: (1) continuing chemical and petrographic characterisation of the Brucejack ores and associated hydrothermal alteration, (2) determining the composition of the mineralising fluids through fluid inclusion analysis, and (3) reconstructing the physiochemical conditions that controlled gold mineralisation through thermodynamic modelling. If successful, our study will improve on existing genetic models for epithermal gold deposits and the strategies that guide their exploration. Locally, it will also improve understanding of the relationship between gold mineralization at Brucejack and Cu-gold-(Mo) mineralization in adjacent world-class porphyry deposits of the Sulphurets camp.