# SEG 100 Conference: Celebrating a Century of Discovery

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## Vertical Variability from Epithermal Gold to Porphyry Copper Mineralization: Toodoggone District, Northern British Columbia, Canada

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The vertical transition between the epithermal and porphyry realms can range from a few 100 m to several kilometers. The depth at which porphyry copper deposits may occur beneath epithermal-type mineralization is highly speculative, and a lack of understanding of those relationships has resulted in failures related to deep-drilling efforts. However, geological and alteration mapping supported by analytical data can effectively recognize and constrain the likely occurrence depth of a porphyry target.

The Toodoggone district in the Stikine terrane of northeastern British Columbia is one of few mineral districts in BC and worldwide that hosts several well-preserved Jurassic high- and low-sulfidation epithermal-type deposits and occurrences.

New age relationships suggest that epithermal-type deposits formed contemporaneously with pluton emplacement and porphyry-type alteration at depth. The 193.8±0.8 Ma Re-Os age from Baker mine overlaps with nearby 193.4±2.6 Ma K-feldspar-altered granodiorite. Similar relationships are evident for epithermal-type mineralization at Alunite Ridge and the 189.6±2.1 Ma K-silicate-altered granodiorite, which hosts porphyry copper mineralization at the Sofia.

Mineral assemblages indicate that some of the epithermal-type veins that were previously classified as low-sulfidation have alteration features indicative of shallow-level porphyry systems. Quartz-sericite-pyrite alteration lacking kaolinite occurs at Baker mine and Black Gossan. White micas at these localities are moderately crystalline (>1.75 index) and K-rich on the basis of SWIR data. Occurrences of pyrophyllite with quartz-sericite alteration at the Brenda indicate shallow porphyry rather than alteration related to epithermal environment.

The occurrence of banded quartz-magnetite±pyrite±chalcopyrite veins in drill holes at the Baker mine indicates a transition toward porphyry alteration 100-150 m below the surface. Such K-silicate alteration occurs in several valley cuts into the deeper-exposed plutons in the district such as at Black Gossan, suggesting that porphyry-level alteration is exposed.

Fluid inclusion analysis indicates near-surface exposures of high-temperature (up to 556°C) and saline (up to 50 wt % NaCl equiv) fluids associated with quartz veins at the Baker mine that are characteristic of porphyry-type alteration at depth. More importantly, these fluids occur only 100-200 m below the surface where lower-temperature (<358°C) and dilute (<2.6 wt % NaCl) fluids caused pervasive sericite alteration and gold-bearing quartz veins. Similar low- to moderate-temperature fluids were also recognized at Black Gossan and Alunite Ridge.

The transition to a porphyry center is further supported by high concentrations of Cu, Mo, W, and Sn, which are typically enriched in the core of porphyry system, relative to Sb, As, Ag, Li and Tl, which are enriched in shallow levels. A normalized element ratio, the MDRU Porphyry Index, is developed (Fig. 1). This index indicates that Sofia and Baker mines have a distinct porphyry character, and prospects such as Shasta, Cliff Creek, Black Gossan, and Alunite Ridge have notable porphyry proximity.

Results show that a range of mineralization types are exposed within a ~1-km vertical profile in the Toodoggone district that formed episodically over from 196 to 186 Ma. The vertical framework proposed herein provides vectoring considerations for the exploration of porphyry-type copper deposits in areas previously explored for only epithermal mineralization.

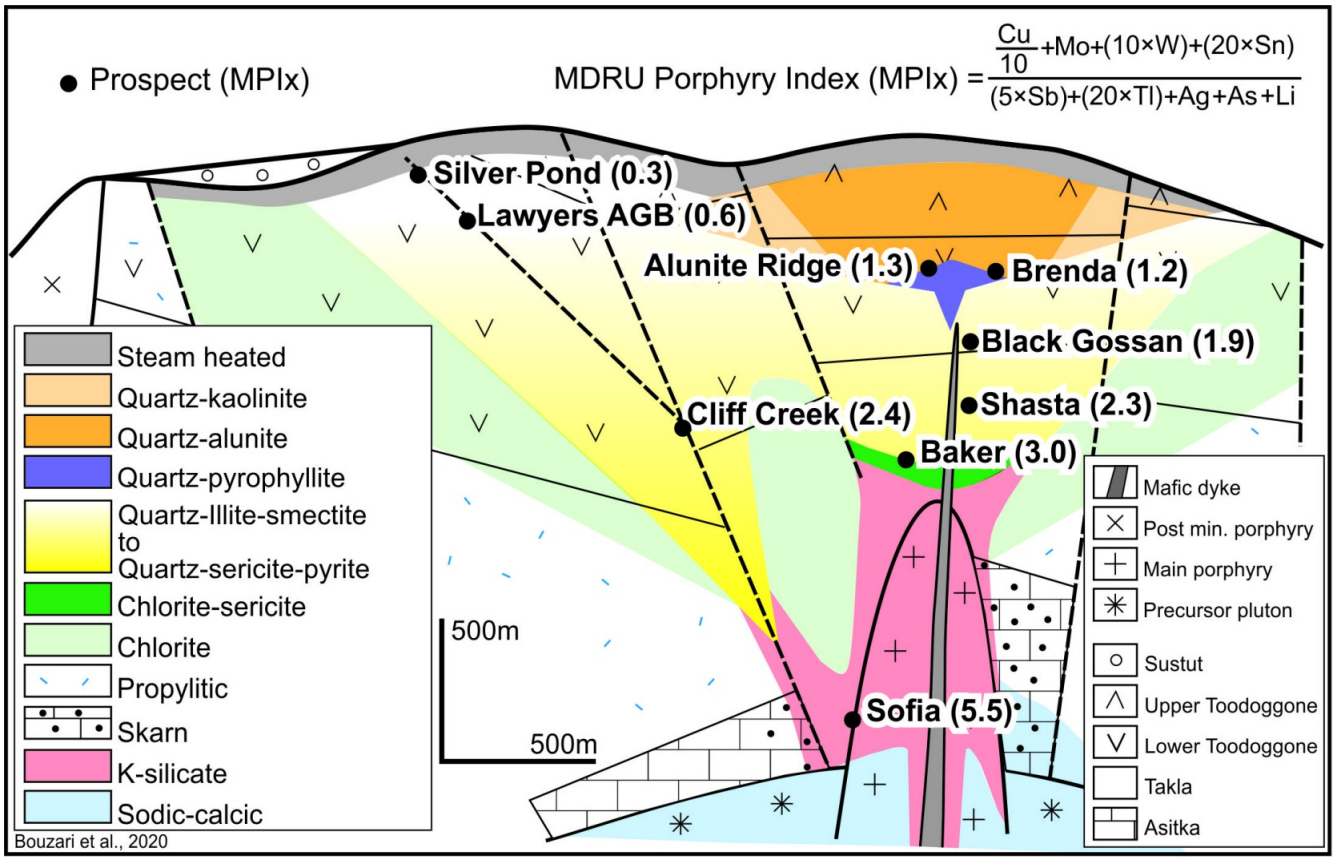


Figure 1: Generalized cross section of the Toodoggone district showing vertical setting of mineral deposits and prospects relative to the typical porphyry alteration zoning (based on Sillitoe, 2010).