AAPG Search and Discovery Article #90172 © CSPG/CSEG/CWLS GeoConvention 2010, Calgary, Alberta, Canada, May 10-14, 2010

Regional and Local Structural Controls on the Distribution of Jurassic Porphyry Cu-Au-Mo and Epithermal Au-Ag Deposits in the Toodoggone District of North-Central British Columbia, Canada

Stephen M. Rowins*, Paul Duuring, Bradley S.M. McKinley, and Jenni M. Dickinson

The University of British Columbia, Department of Earth and Ocean Sciences, Vancouver, British Columbia, Canada V6T 1Z4

Larry J. Diakow
British Columbia Geological Survey, Victoria, British Columbia, Canada V8W 9N3

Robert A. Creaser
University of Alberta, Department of Earth and Atmospheric Sciences, Edmonton, Alberta, Canada T6G 2E3.

* Now at the British Columbia Geological Survey

Abstract

The Toodoggone district is a 100 km long and 30 km wide NNW-trending belt of mainly Jurassic volcano-plutonic island arc rocks located within the Intermontane Belt of the Stikine terrane in north-central BC. The district hosts Kemess South, the largest gold mine in BC (produced 171,600 oz Au and 23,500 t Cu in 2009), and contains several other significant calc-alkaline porphyry Cu-Au-Mo (Kemess North and Pine) and epithermal Au-Ag (Shasta, Baker, and Lawyers) deposits (Figure 1). Possible genetic linkages between porphyry and epithermal deposits in the district were investigated during a 3-year NSERC-CRD project (2004-2007) by integrating district-scale geological mapping and geochronological studies with detailed deposit models of the key porphyry and epithermal systems (Duuring et al., 2009a; 2009b). Episodic plutonism from ca. 218 to 190 Ma coincided with the formation of the largest porphyry Cu-Au (Mo) systems from ca. 202 to 197 Ma, with only minor porphyry mineralization occurring from ca. 197 to 194 Ma. Porphyry systems are spatially restricted to exposed Asitka and Takla Group basement rocks and, more rarely, the lowest member of the Hazelton Group (i.e., the ca. 201 Ma Duncan Member). These country rocks are most commonly exposed in the southern half of the district where high rates of erosion and uplift have resulted in their preferential exposure. In comparison, low- and high-sulfidation epithermal systems are more numerous in the northern half of the district, where younger overlying Hazelton Group rocks are mainly exposed. High-sulfidation epithermal systems formed at ca. 201 to 189 Ma, whereas low-sulfidation systems developed at ca. 196 to 186 Ma, demonstrating a temporal coincidence with porphyry systems elsewhere in the district.

Historically, most low-sulfidation epithermal systems in the Toodoggone district were considered to be unrelated to porphyry systems. Rather, these deposits were interpreted

to have formed in steeply dipping extensional growth faults that correspond to the margins of large NW-trending grabens or half-grabens (e.g., Vulimiri et al., 1986). An analogy may be drawn with the low-sulfidation "range-front" type epithermal Au-Ag deposits of the Tertiary Basin-and-Range metallogenic province of southwestern United States (Diakow et al., 1991). The basinal growth faults in the Toodoggone district were interpreted to have focused not only the ascent of regionally heated metalliferous fluids (mainly meteoric waters), but also the eruption of volcanic rocks of the Toodoggone Formation (Diakow et al., 1991). A "fissure-style" eruption explains both the lack of calderas in the Toodoggone district and how a 2,200 m thick (minimum) section of Toodoggone Formation rocks were deposited. There is compelling geological and geochemical evidence, however, that magmatic-hydrothermal fluids were directly involved in the genesis of some epithermal systems. This evidence includes the existence of high-sulfidation epithermal deposits, which typically overlie porphyry systems, and the finding that some low-sulfidation epithermal deposits formed from hot (>450 C), saline, aqueous fluids with isotopic values (S, C, O, and Pb) indicating the involvement of magmatic fluids (i.e., Baker). These data strongly suggest that two distinct styles of hydrothermal fluid flow were operative in the Toodoggone during the Early Jurassic and both were capable of generating significant epithermal Au-Ag mineralization.

Deposit mapping has shown that the far-field stress conditions that produced the regional NW- and NE-trending normal faults also caused structural modification of the porphyry orebodies. At the Kemess North deposit, all rocks, including the Kemess North diorite are cut by a deposit-scale, E-striking normal fault that dips steeply to the north and extends in strike length for at least 1.4 km and to depths of 500 m below the present surface. The fault marks the contact between the Takla Group and Toodoggone Formation rocks. This E-striking normal fault is cut by NW- to NNE-striking faults that show normal-dextral displacements. These post-ore faults cause blocks of Toodoggone Formation rocks to be vertically displaced downwards relative to adjacent Takla Group basalt. This geometry results in horst-and-graben style block faulting of the Kemess North orebody. These structural relationships are repeated at the Kemess South Mine where the entire Au-Cu orebody is down-dropped to the S by the E-striking, steeply S-dipping, normal North Block Fault (NBF). Consequently, the monzonite/andesite hosting the orebody is tectonically juxtaposed against unmineralized Asitka chert (Figure 2). Finally, young NW- and NE-striking faults cut all rock-types, orebodies, and the NBF with normal dextral displacements producing the same horst-and-graben style of block faulting seen at Kemess North.

References

Diakow, L. J., Panteleyev, A., and Schroeter, T. G., 1991, Jurassic epithermal deposits in the Toodoggone River area, Northern British Columbia: Examples of well-preserved, volcanic-hosted, precious metal mineralization: Economic Geology, 86, 529-554.

Duuring, P., Rowins, S. M., McKinley, B. S. M., Dickinson, J. M., Diakow, L. J., Kim, Y-S., and Creaser, R. A., 2009a, Magmatic and structural controls on porphyry-style Cu-Au-Mo mineralization at Kemess South, Toodoggone district of British Columbia, Canada: Mineralium Deposita, 44, 435-462.

Duuring, P., Rowins, S. M., McKinley, B. S. M., Dickinson, J. M., Diakow, L. J., Kim, Y-S., and Creaser, R. A., 2009b, Examining potential genetic links between Jurassic porphyry Cu-Au-Mo and epithermal Au-Ag mineralization in the Toodoggone district of north-central British Columbia, Canada: Mineralium Deposita, 44, 463-496.

Vulimiri, M. R., Tegart, P., and Stammers, M. A., 1986, Lawyers gold-silver deposits, British Columbia: Canadian Institute of Mining and Metallurgy Special Volume 37, 191-201.

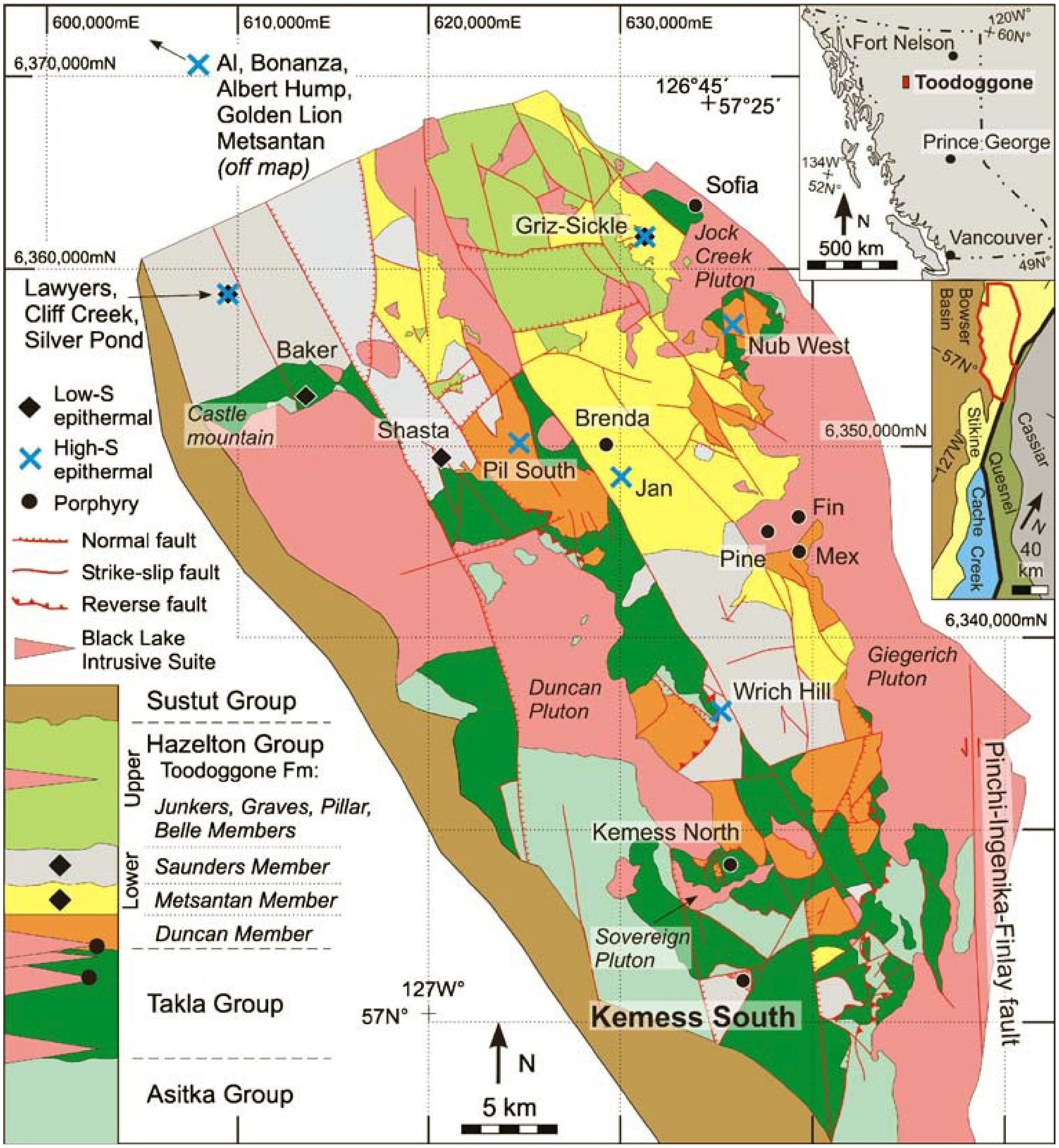

Figure 1: Simplified geology map of the southern half of the Toodoggone district.

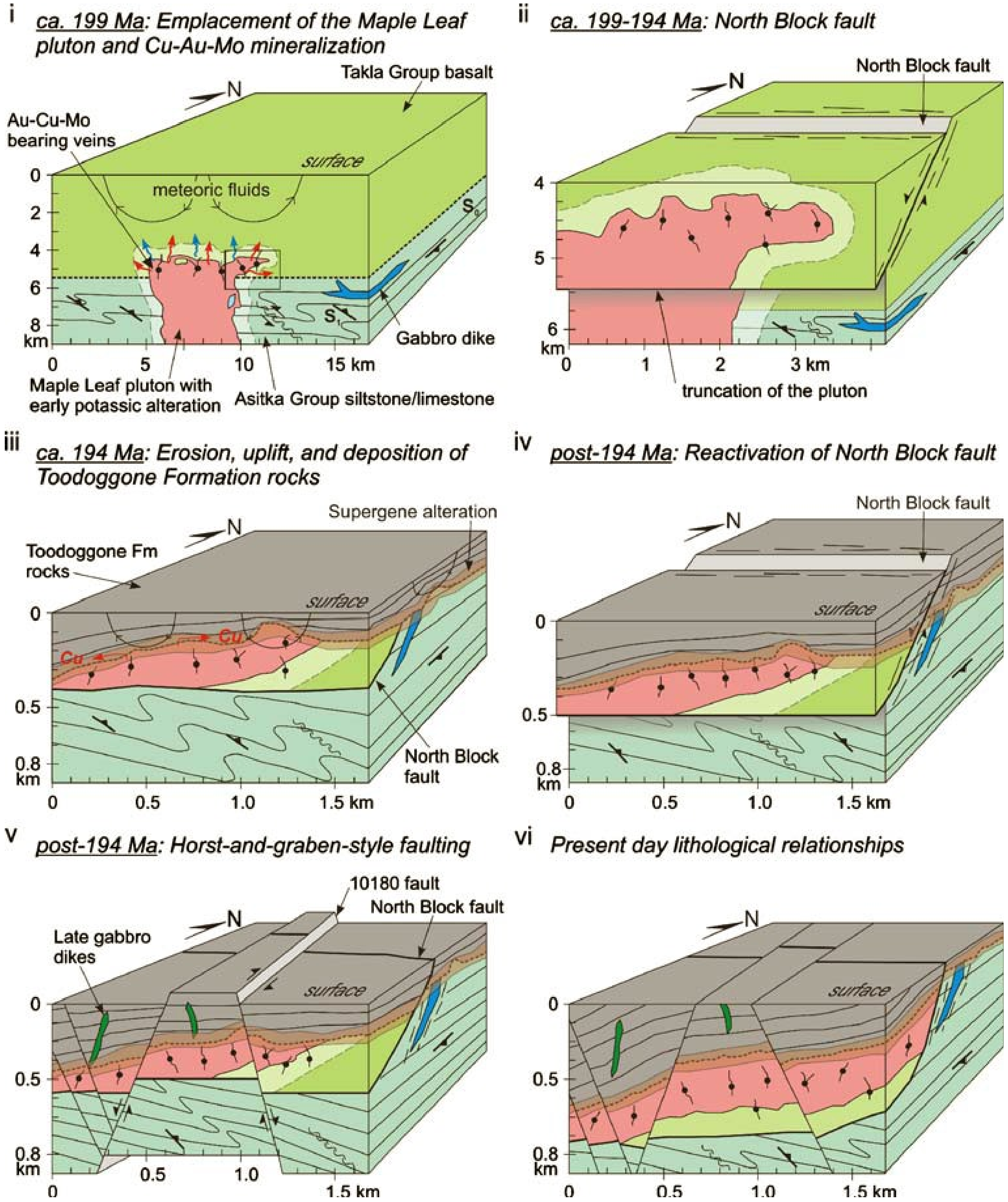

Figure 2: Genetic model showing the sequential evolution of the Kemess South deposit.