Sulfur Isotopic Zonation in Alkalic Porphyry Cu-Au Systems: Applications to Mineral Exploration in British Columbia

By Cari L. Deyell Shane Ebert and Richard M. Tosdal

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Alkalic Au-Cu porphyry deposits are associated with alkalic or high-K calc-alkalic igneous rocks. The deposits also have distinctive alteration zones, including sodic and calc-potassic assemblages. These deposits occur in only a few mineral provinces worldwide and some of the best-known examples are from British Columbia (e.g., Galore Creek, Mt. Polley, Afton/Ajax, Copper Mountain). The Lachlan Fold Belt of New South Wales, Australia is the second largest alkalic porphyry district (e.g., Cadia, Goonumbla) and other isolated alkalic systems are known from the Philippines (Dinkidi), Greece (Skouries), Colorado (Allard Stock) and Mongolia (Oyu Tolgoi). Alkalic porphyry deposits are of increasing economic significance and represent some of the world's highest-grade porphyry gold resources (e.g., Cadia, Australia). In B.C., the largest alkalic porphyry systems (Copper Mountain, Mount Milligan, and Galore Creek) have a combined resource of over 900 Mt (Lang et al., 1995), and new discoveries at Afton and Lorraine may significantly add to this figure. These deposits are difficult exploration targets, however, since high-grade deposits are associated with small volume pipe-like intrusions that may have areal extents of only a few hundred square meters (e.g., Wilson et al., 2002). The alkalic systems have no associated advanced argillic alteration assemblages, and phyllic alteration is typically restricted to deep-penetrating fault zones. Supergene enrichment zones will therefore be poorly developed at best due to the low sulfide contents of the alteration assemblages (Cooke et al., 2002). The lack of extensive peripheral hypogene alteration assemblages makes identifying the focus for fluid flow difficult when more than several hundred meters away from the mineralized porphyry centre. Effective exploration therefore requires the means to recognize subtle alteration zones or geochemical halos that highlight proximity to an alkaline intrusive centre.

Preliminary research into the alkalic porphyry deposits of Australia has suggested that systematic vertical and lateral sulfur isotopic zonation may occur around several mineralized porphyry complexes (e.g., Goonumbla and Cadia: Lickfold, 2001; Wilson, 2003). Data collected by the Centre for Ore Deposit Research (CODES) at the University of Tasmania indicates sulfide compositions in these systems are between –2 and –10‰. The most negative values lie towards the top of the mineralized monzonite pipes, with a transition to near zero values with distance upwards or outwards from the pipe (Lickfold, 2001; Wilson, 2003). The initial studies lead to the obvious question of whether sulfur isotopes provide the "magic-

Cari L. Deyell < cdeyell@utas.edu.au> University of Tasmania, Hobart, Tasmania, Australia

Shane Ebert sebert@eos.ubc.ca and Richard M. Tosdal < rtosdal@eos.ubc.ca> The University of British Columbia, Vancouver, British Columbia

bullet" for exploration in these system. Before sulfur isotope mapping can be widely applied however, it must be established whether the zonation is a phenomenon common to these deposits on a worldwide basis.

The current study aims to test whether systematic sulfur-isotopic zonation of sulfide and sulfate minerals characterizes alkalic porphyry deposits in British Columbia. If this zonation proves to be a robust and predictable phenomena, then it could be a highly valuable tool in the exploration for new mineral deposits (or extensions to known ore bodies) in the alkalic porphyry provinces of British Columbia.

Research in this study is focused on several sites including Galore Creek, Afton, Lorraine, Mt. Polley, and Red Chris. Over 250 samples from these deposits will be analyzed by conventional sulfur isotope methods at the University of Tasmania, Australia. Preliminary results from two of these sites (Afton and Galore Creek) indicate a wide range of sulfide $\delta^{34}S$ values from –11.3 to +16.9‰. All results will be reported to the Rocks to Riches program and, if a consistent sulfur isotope zonation is recognized, the origin and significance of this zonation and its applicability to other deposits will be tested by further study.

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