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Reduced and Oxidized Au-Cu-Bi Iron Oxide Deposits of the Tennant Creek Inlier, Australia: An Integrated Geologic and Chemical Model

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Abstract

Iron oxide-associated Au-Cu-Bi deposits of the Tennant Creek gold field range from magnetite-pyrrhotite-pyrite (reduced) Cu-rich deposits, through sulfide-poor, magnetite-rich high-grade Au-Bi (intermediate-f_{O_2}) deposits, to hematite-rich high-grade Au (oxidized) deposits. Discordant magnetite-hematite-chlorite-quartz ironstone bodies that host the ore formed hydrothermally during the ~1840 to 1860 Ma Barramundi orogeny at temperatures up to ~350° to 400°C and ~2.5 to 5(?) kbars. Deposition of ironstone minerals was localized by dilatency that was generated during D_1 reverse shearing and folding. A separate Au-Cu-Bi hydrothermal stage overprinted selected ironstones during D_2 at or before ~1825 to 1830 Ma, where favorable D_1 structures and fluid pathways were reactivated.

The extremes of the reduced- to oxidized-deposit spectrum represent divergent chemical conditions that cannot be reconciled by the action of a single fluid. We have identified both reducing and oxidizing fluids that helped to form the Au-Cu-Bi deposits. At the West Peko deposit, which represents the reduced end-member subtype, constraints from oxide-silicate-sulfide mineral stabilities, fluid inclusions, and chlorite thermochemistry indicate that Au-Cu-Bi ore was introduced into ironstone at 300° to 340°C by a reducing (pyrrhotite-stable), weakly acidic, sulfur-rich and N_2-CH_4–rich aqueous fluid containing 3 to 10 wt percent NaCl equiv. An ore fluid source outside the relatively oxidized metasedimentary host sequence (Warramunga Formation) is implied. We suggest similar ore fluids for other reduced Cu- and sulfide-rich deposits in the district. Chemical mass transfer modeling of reactions between reducing fluid and ironstone, incorporating estimated thermodynamic properties for aqueous bismuth complexes, indicates that highly efficient gold and native Bi deposition was predominantly in response to desulfidation and oxidation of the fluid. Chalcopyrite precipitated mainly in response to increased pH.

Gold-bismuth ore in the Eldorado deposit, an oxidized and hematitic end member, is interpreted to have involved mixing of an oxidizing (hematite-stable) Ca-Na-Cl brine with an intermediate-f_{O_2}, low- to moderate-salinity ore fluid, as well as reaction of both fluids with ironstone. Furthermore, the mass transfer modeling suggests that mixing of reducing and oxidizing fluids in the absence of ironstones could have resulted in high-grade Au deposits lacking Fe oxides, a subtype that has received comparatively little exploration attention in the Tennant Creek district.