

Geological Characterization of an Archean Oxidized Intrusion-Related Au-Cu(-Mo) Deposit: The Upper Beaver Deposit, Kirkland Lake, Canada

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The nature and origin of intrusion-related Au systems in the Archean is disputed, partly due to ambiguous features and preservation issues. In contrast, the ca. 2680 Ma Upper Beaver Au-Cu (Mo) deposit (reserves 23.2 Mt grading 3.71 g/t and 0.24% Cu; Agnico Eagle Mines, 2025) of the Abitibi greenstone belt (Ontario, Canada) preserves unequivocal evidence of an Archean magmatic-hydrothermal setting. The host ca. 2703 Ma bimodal volcanic-plutonic rocks of the Blake River Group are cut by a ca. 2680 Ma polyphase hypabyssal intrusive complex with pre-, syn-, and post-ore phases of mixed mafic and felsic compositions. The main phase of regional deformation variably overprints the system. Mineralization occurs in two types: 1) an early concordant replacement-style skarn-like assemblage localized along faults, stratigraphic contacts, and hosted in premineral intrusions; and 2) discordant polymetallic veins forming >90% ore reserve. The early skarn-like and premineral amphibole and plagioclase-amphibole diorites are cut by synmineral amphibole diorite and plagioclase \pm quartz-amphibole monzodiorites. The polymetallic (Fe oxide-Cu-Mo-Au) veins are spatially associated with synmineral plagioclase \pm quartz-amphibole monzodiorite dikes, which splay from the intrusive stock and are themselves cut by polymetallic veins. Hydrothermal alteration hosting the polymetallic veins includes K-Na feldspar, phyllic and iron-oxide alteration, with a distal barren propylitic facies. Ore petrology and lithogeochemistry define a vein paragenesis: early magnetite-hematite-scheelite veins are cut by quartz-molybdenite-pyrite-gold veins centered on the intrusive complex, with later chalcopyrite-pyrite-anhydrite-sulfosalt-gold-telluride veins extending outside the proximal molybdenite zones. Thus, a spatial zonation of vein types is defined extending from an intrusive center. These veins are cut by a postmineralization plagioclase-amphibole diorite dike, which is subsequently overprinted by quartz-carbonate-tourmaline veins. These features suggest an intrusion-related origin for the deposit, related to an oxidized magmatic complex. This indicates potential for similar ore settings spatially associated with hydrous mafic magmatism in Archean terranes.