Cumulates and the Orthomagmatic to Porphyry Transition: New Insights from the Lorraine Cu-Au-Ag Deposit, Quesnel Terrane, Central British Columbia

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Ultramafic-mafic arc cumulates offer rare glimpses into primitive melt evolution and transport through the middle to upper crust of accretionary orogens. In the Quesnel Terrane of British Columbia, Late Triassic to Middle Jurassic ultramafic suites occur as either Alaskan-type complexes (e.g., Tulameen, Polaris) or alkaline pyroxenite-syenite complexes (e.g., Duckling Creek syenite complex, Bootjack stock) that are commonly spatially and/or temporally related to Cu-Au porphyry deposits. The ca. 180 Ma Lorraine Cu-Au-Ag deposit is hosted in the Duckling Creek syenite complex, part of the Hogem Batholith. Host rocks form a crudely zoned clinopyroxenite-syenite complex comprising pre- to syn-mineral clinopyroxenite, melanocratic to leucocratic syenite and monzonite, rare pseudoleucite-bearing syenite, and late-mineral monzodiorite; all units are intruded by post-mineral quartz syenite and syenite dykes. The cumulates are mineralogically and geochemically linked to variable proportions of cumulus minerals (clinopyroxene-biotite-magnetite-apatite-hornblende-alkali feldspar-plagioclase-leucite). Orthomagmatic mineralization is present in three distinct zones – Lower Main, Upper Main, and Bishop – as disseminated to net-textured bornite-digenite, chalcopyrite-bornite, and pyrite-chalcopyrite (± magnetite ± sphalerite), with complex exsolution and symplectite textures associated with abundant Ag-tellurides (hessite), Pb-selenides (clausthalite?), and electrum. Locally, disrupted and partially resorbed sulfide textures occur with muscovite-epidote-chlorite-carbonate ± garnet alteration, and suggest a late, post-mineral fluid overprint. New LA-ICP-MS $^{206}Pb/^{238}U$ zircon dates show initial crystallization at ca. 182-175 Ma with later recrystallization between ca. 160-150 Ma. The younger zircon population displays irregular and disrupted zonation in CL, along with high U and Ce, and low Ti, which is indicative of a low-temperature, oxidized fluid overprint on primary igneous zircon grains. We interpret Lorraine as a rare example of a fractionated, oxidized, mid-crustal Cu-rich orthomagmatic deposit, analogous to Loch Borralan (Scotland), providing new constraints on arc magmatism, emplacement depth, and the orthomagmatic to porphyry Cu-Au transition in island arcs globally.