Gold- and Copper-bearing Quartz Veins Associated with Regional Devonian Extensional Deformation in Rocks on Prince of Wales Island, Southeastern Alaska

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Gold- and copper-bearing epithermal quartz veins mined on central and southern Prince of Wales Island in the early 1900's were described as post-metamorphic shear-hosted quartz veins by previous workers. We bracket the age of these mineralized quartz veins with ages of metamorphic minerals in their host rocks and ages of intrusive rocks that predate and postdate the mineralized veins. Mineralized quartz veins at the Moonshine deposit parallel the flattening fabric in the Wales Group. Strike-parallel extension, indicated by subhorizontal stretching lineations, subvertical boudins, and extensional gash veins, is dated by metamorphic minerals in the Wales Group. New ^{40}Ar-^{39}Ar mica ages from Wales Group schist and gneiss range from approximately 413 to 390 Ma. Gold-bearing quartz veins at the Flagstaff mine fill shear structures that cut the Wolf Lake pluton at the head of Kasaan Bay. A new hornblende ^{40}Ar-^{39}Ar age of 410 Ma for the pluton at Wolf Lake is similar to previously published U-Pb zircon ages ranging from 400 to 430 Ma for plutons on the Kasaan Peninsula. Polymetallic quartz veins on the Kasaan Peninsula are associated with sodic plagioclase porphyritic dikes that are ubiquitous in the Kasaan Bay area. Some of these porphyry dikes cut sulfide mineralization; quartz-calcite-calc-silicate-sulfide stringers permeate some dikes; some porphyry dikes are locally replaced by sulfide ore. The sodic porphyry dikes locally intrude the Wolf Lake and Kasaan plutons and commonly occur in swarms. Porphyritic rhyolite sills, tuff layers, and clasts in fossiliferous Emsian limestone on Kasaan Island indicate an Emsian (397-407 Ma) age for the porphyritic dikes. Late, undeformed, unmineralized diabase dikes that have similar chemistry to the mafic and ultramafic rocks in the Kasaan area cut quartz veins at the Flagstaff mine, the Salt Chuck intrusions, the porphyry dikes on the Kasaan Peninsula, and are inferred to represent the final phase of the Devonian magmatic event.

The Salt Chuck ultramafic bodies at the head of Kasaan Bay crosscut fold structures in the Silurian-Ordovician Descon Formation. The Salt Chuck bodies are clinopyroxene-magnetite cumulates with postcumulus plagioclase and biotite. Layering of cumulus phases indicate Salt Chuck intrusions are folded in synformal and antiformal structures. A new ^{40}Ar-^{39}Ar biotite age of 439.7 ± 2.6 Ma for the Salt Chuck ultramafic complex indicate it is older than the Wolf Lake and Kasaan intermediate-composition plutons. Mineralization at Salt Chuck has been described in two phases: 1) disseminated Fe-PGE mineralization in cumulus phases, and 2) Fe-Cu-Pd mineralization precipitated in calcite-chlorite veins associated with Hg, well after solidification of the ultramafic bodies. Chalcopyrite occurrences around Salt Chuck are reported to be mainly confined to fault zones, and associated with Au, Ag, Pd, and minor Pt. Low temperature metal-bearing

hydrothermal fluids post-dating emplacement of the Salt Chuck ultramafic intrusions could produce the anomalously high Cu-Ni and Pd-Pt ratios that characterize the Salt Chuck deposit.

Fe-skarn and magnetite deposits on the Kasaan Peninsula are folded with their greenstone and calcareous sedimentary host rocks. The magnetite bodies contain little or no Cu. The folded magnetite bodies are intruded by several generations of planar Early Devonian diorite and basaltic, andesitic, dacitic, and rhyolitic sodic porphyry dikes that strike NW and NNE. The dikes parallel regional structures and have been interpreted by all workers to be syntectonic. The magnetite bodies only occur along the SW margin of the Kasaan Peninsula, on trend with Salt Chuck, and this distribution is confirmed by an aeromagnetic geophysical survey. We infer that the magnetite bodies are coeval with the Salt Chuck intrusion, and predate the Devonian deformation represented by both the folding of the magnetite-rich mafic-ultramafic bodies and the structures filled with crosscutting NW and NNE Devonian diorite and porphyry dikes on the Kasaan Peninsula. Sulfide ores on the Kasaan Peninsula mostly occur separately from the magnetite ores, are associated with emplacement and alteration of the porphyry dikes and with faults that postdate the porphyry dikes, and typically contain about 10% Cu with minor Au. These Cu-Au sulfide ores are apparently coeval with the Cu-quartz veins in extensional structures that cut the Wales gneiss at Moonshine, the Au-quartz veins in tensional shears that cut the Wolf Lake pluton, and the high Cu/Ni and Pd/Pt veins that cut the Salt Chuck pyroxenite intrusion. We conclude that these low-temperature Cu- and Au-bearing fluids may have been generated during a regional Devonian tectonic-magmatic event that affected southern Prince of Wales Island.

Pb isotopic analyses on galena from the polymetallic quartz veins that intrude the Wales Group indicate mixed radiogenic and nonradiogenic sources, compatible with remobilization of Pb from primitive Cambrian-Proterozoic Wales Group basement rocks during Devonian regional metamorphism. Pb isotopic compositions from veins that intrude the Silurian-Ordovician Descon Formation near Kasaan Bay reflect similar combinations of radiogenic and nonradiogenic sources, possibly including lead from younger country rocks than the Wales Group. These epithermal polymetallic quartz vein deposits are coeval with retrograde greenschist facies metamorphism of the Wales Group, regional northwest-southeast-trending extensional structures, alkalic dike swarms, and regional uplift, which is represented by widespread unmetamorphosed Early Devonian basal conglomerate with redbeds. There is no evidence for post-Devonian regional metamorphism on Prince of Wales Island. Structures on Prince of Wales Island associated with the Cretaceous collision of the Alexander terrane with North America are brittle thrust faults and crenulation cleavages that lack associated quartz veins. We infer that the polymetallic quartz veins on Prince of Wales Island fill extensional structures associated with late stages of uplift at the end of the Devonian regional tectonic-magmatic event. The numerous dike swarms along the NW-trending Kasaan Bay often exceed 70% of outcrops in which they occur, indicating significant extension. The combined evidence supports Early Devonian transtensional faulting as the tectonic environment for uplift of these rocks through greenschist facies cooling temperatures and the extension that fostered Early Devonian dike swarms along the trend of Kasaan Bay.