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The Late Cretaceous Donlin Creek Gold Deposit, Southwestern Alaska: Controls on Epizonal Ore Formation

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Abstract

The Donlin Creek gold deposit, southwestern Alaska, has an indicated and inferred resource of approximately 25 million ounces (Moz) Au at a cutoff grade of 1.5 g/t. The ca. 70 Ma deposit is hosted in the Late Cretaceous Kuskokwim flysch basin, which developed in the back part of the arc region of an active continental margin, on previously accreted oceanic terranes and continental fragments. A hypabyssal, mainly rhyolitic to

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rhyodacitic, and commonly porphyritic, 8- × 3-km dike complex, part of a regional ca. 77 to 58 Ma magmatic arc, formed a structurally competent host for the mineralization. This deposit is subdivided into about one dozen distinct prospects, most of which consist of dense quartz ± carbonate veinlet networks that fill north-northeast–striking extensional fractures in the northeast-trending igneous rocks. The sulfide mineral assemblage is dominated by arsenopyrite, pyrite, and, typically younger, stibnite; gold is refractory within the arsenopyrite. Sericitization, carbonatization, and sulfidation were the main alteration processes.

Fluid inclusion studies of the quartz that hosts the resource indicate dominantly aqueous ore fluids with also about 3 to 7 mol percent CO_2 ± CH_4 and a few tenths to a few mole percent NaCl + KCl. The gold-bearing fluids were mainly homogeneously trapped at approximately 275° to 300°C and at depths of 1 to 2 km. Some of the younger stibnite may have been deposited by late-stage aqueous fluids at lower temperature. Measured $\delta^{18}O$ values for the gold-bearing quartz range between 11 and 25 per mil; the estimated $\delta^{18}O$ fluid values range from 7 to12 per mil, suggesting a mainly crustally derived fluid. A broad range of measured δD values for hydrothermal micas, between –150 and –80 per mil, is suggestive of a contribution from devolatilization of organic matter and/or minor amounts of mixing with meteoric fluids. Gold-associated hydrothermal sulfide minerals are characterized by $\delta^{34}S$ values mainly between –16 and –10 per mil, with the sulfur derived from diagenetic pyrite and organic matter within the flysch basin. A smaller group of $\delta^{34}S$ measurements, which shows values as depleted as –27 per mil, suggests a different local sulfur reservoir in the basin for the later hydrothermal episode dominated by stibnite. Initial ε_{Nd} of –8.7 to –3.1 and $^{87}Sr/^{86}Sr$ measurements of 0.706 to 0.709 for the ore-hosting dikes also indicate a crustal reservoir for some of the Late Cretaceous magmatism. Overlapping lead isotope data for these intrusive rocks and for sulfide minerals suggest a crustal contribution for the lead in both.

Copper- and gold-bearing stockwork veinlets in hornfels occur at Dome, a prospect located at the northern end of the Donlin Creek deposit. These stockworks are cut by the younger auriferous gold veins that define the main Donlin Creek gold mineralization. Highly saline, gas-rich, heterogeneously trapped fluids deposited the stockworks at temperatures approximately 100°C hotter than those of the main gold-forming event at Donlin Creek. The genetic relationship of the Dome prospect to the main Donlin Creek gold resource is equivocal.

The epizonal Donlin Creek deposit shows affinities to the gold systems interpreted by various workers as orogenic or intrusion related; it shows important differences from typical epithermal and Carlin-like deposits. The ore-forming fluids were derived by either broad-scale metamorphic devolatilization above rising mantle melts or exsolution from a magma that was dominated by a significant flysch melt component.