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Geochemical and Mineralogical Variation of Gold Mineralization Across the Dakotan Tectonic Zone, Black Hills, South Dakota – A Crustal Continuum of Orogenic Gold Deposits

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The Black Hills of South Dakota hosts the world-class 60 Moz Homestake Mine (the type locality for iron formation-hosted gold deposits). Recent recognition of a brittle-ductile shear zone system across the entire Black Hills, the Dakotan Tectonic Zone (DTZ), has provided an updated framework for exploring shear-hosted orogenic gold mineralization in the region. Orogenic gold deposits in this Paleoproterozoic volcano-sedimentary basin resulted from complex polyphase metamorphism, deformation, hydrothermal fluid flow, and granitic magmatism during arc accretion and subsequent suturing of the Superior and Wyoming Provinces.

Gold occurrences across the greater Black Hills are found proximal to mapped DTZ structures in varied geodynamic settings, within varied host lithologies subject to metamorphic conditions ranging from upper amphibolite to subgreenschist facies, each with distinct geochemical associations. The occurrences and deposits in the eastern and central Black Hills are characterized by host rocks including siliceous metagraywackes, carbonaceous phyllites, and iron formations with sericite-graphite-tourmaline+/-chlorite alteration and an intimate Au-As(+/-Ag, Sb, Pb, Zn) association, with a 0.56 log-scale correlation coefficient for samples within a 500-km^2 area. Using the As-in-arsenopyrite geothermometer, mineralization temperature estimates from the Homelode Trend, Homestake Mine, and the Keystone Trend range from <290°-470°C. Though all ore depositional textures indicate a postpeak metamorphic timing, relative differences in estimated mineralization temperatures correlate well to differences in peak metamorphic and textural characteristics observable in the field and thin sections. In contrast, in the southwestern Black Hills, gold mineralization is hosted in shear zones within upper amphibolite facies alkalic mafic rocks and pelitic schists, with strong correlations between Au-Bi-Te-V and pervasive tourmaline(schorl-dravite)-graphite-sillimanite alteration. Sillimanite alteration, along with mineralogical textures within mineralized quartz veins, may be attributable to immiscible Bi melts and/or carbonic fluids, suggesting mineralization temperatures above 500°C. The postmetamorphic timing of host shear zones, tourmaline alteration, and high-temperature estimates for mineralization are consistent with mineralization driven by the intrusion of Harney Peak Granite, which is also responsible for nearby tourmaline-rich pegmatite dikes, satellite intrusions, and metasomatic tourmalinites. Together, these gold deposits and occurrences represent orogenic gold subtypes including epizonal, mezozonal, and hypozonal deposits and provide an example of multiple gold mineralization styles emplaced at distinct crustal levels in diverse host rocks within a single district—a departure from the iron formation dominated model previously ascribed to the area.