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Mineralogy and mineral chemistry of the Sunrise Dam orogenic gold deposit, Western Australia

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The Sunrise Dam mine is the largest gold deposit in the Archean Laverton Tectonic Zone of the Eastern Goldfields Province, Yilgarn Craton, Western Australia. Mineralogical studies have established a paragenetic sequence consisting of five hydrothermal stages (D_1, D_2, D_3, D_{4a} and D_{4b}). The D_{4a} stage was the dominant episode of Au deposition, followed by the D_{4b} stage, which is characterized by more diverse ore mineralogy including base metal sulfides, sulfosalts, and telluride minerals. Based on EPMA results, native gold in D_{4a} stage has higher purity, with a small range of Ag variations (fineness 923 ~ 977, average 945), than that of the D_{4b} stage (fineness 596 ~ 983, average 899), in which fineness values decrease systematically in accord with mineral paragenesis. The occurrences of As-rich pyrites are restricted to steeply-dipping ore bodies, which are most likely structurally connected at various level by channel ways through which As-rich (D_{4a}) hydrothermal fluid migrating upward. There is a systematic variation in composition of the tetrahedrite-group minerals ranging from Sb to As end-members with highly variable Zn:Fe ratios, which correlates with the later paragenetic stages (D_3, D_{4a}, and D_{4b}) and mineral associations. A total of thirteen telluride mineral species, including two unnamed phases, were identified in the D_4 veins. During the D_{4b} stage, Au-richer telluride and Au-richer native gold mineralization formed earlier than Ag-(Au)-telluride and Ag-richer gold mineralization. Values of $f(Te_2)$ and $f(S_2)$ for the early telluride assemblages were determined at 300°C to be −10.7 to −7.8 (log fTe_2) and 11.4 to −8.6(log fS_2). Small-scale remobilization during dissolution-reprecipitation (D_{4a}) and recrystallization (post-D_{4b}) processes resulted in the Au enrichment and the upgrading of Au during successive hydrothermal events in the deposit. The speciation of Au at Sunrise Dam and the exceptional size of the deposit are the result of multiple fluid flow and multiple Au-precipitating mechanisms over a single plumbing system.