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Geochronological Constraints on Pre-, Syn-, and Postmineralization Events at the World-Class Cleo Gold Deposit, Eastern Goldfields Province, Western Australia

S. M. Brown,† I. R. Fletcher,

Centre for Global Metallogeny, Department of Geology and Geophysics, University of Western Australia, Crawley, Western Australia 6009, Australia

H. J. Stein,

AIRIE Program, Department of Earth Resources, Colorado State University, Fort Collins, Colorado 80523

L. W. Snee,

U.S. Geological Survey, Mail Stop 974, Denver Federal Center, Denver, Colorado 80225

and D. I. Groves

Centre for Global Metallogeny, Department of Geology and Geophysics, University of Western Australia, Crawley, Western Australia 6009, Australia

Abstract

Recent geological and geochronological studies have led to a reevaluation of whether or not the majority of the lode gold deposits of the Yilgarn craton formed nearly synchronously during an Archean craton-wide hydrothermal event, as previously proposed. The majority of reliable data indicate that gold mineralization took place at ca. 2640 to 2625 Ma; however, recent work in the far north of the Eastern Goldfields province provides structural evidence for instances of earlier gold mineralization and geochronological data for interpreted postore rocks that are considerably older than 2640 Ma. The documentation of xenotime and monazite in association with ore minerals at the Cleo deposit provides a valuable means of determining the absolute age of gold mineralization.

At the Cleo deposit, high-grade Western Lodes veins crosscut the Sunrise shear zone at a high angle with only centimeter-scale offset. Given that the stratigraphic sequence indicates at least several hundred meters offset across the shear zone, the minimal offset of the Western Lodes veins indicates that gold mineralization was late in the history of movement in the shear zone. The absolute ages of pre-, syn-, and postmineralization elements in the mine stratigraphic succession have been determined using a variety of geochronological techniques. Fuchsite micas formed in the Sunrise shear zone yield an $^{40}Ar/^{39}Ar$ isochron age of 2667 ± 19 Ma. Rhyodacite porphyry dikes postdate the formation of the shear zone but predate the main phase of gold mineralization. Dike intrusion is constrained to 2674 ± 3 Ma by SHRIMP II U-Pb analysis of zircons from these dikes. Rhenium-Os analysis of molybdenite from quartz + chalcopyrite + molybdenite veins that crosscut the porphyry dikes gives an age of formation at 2663 ± 11 Ma, consistent with their relationship to the porphyry dikes. Both the dikes and these veins are crosscut by gold-bearing Western Lodes veins. Mutually crosscutting relationships with ore minerals indicate that microscopic xenotime and monazite grains were deposited during ore formation in the Western Lodes ore zones. SHRIMP II U-Pb analyses of xenotime and monazite grains indicate that Western Lodes mineralization took place at 2654 ± 8 Ma, at least 9 m.y. after the intrusion of the porphyry dikes (95% confidence). Evidence for substantial temporal separation between intrusive activity and gold mineralization is recorded by other researchers for other deposits associated with granitic intrusions in the Leonora-Laverton area. Phlogopitic micas from a lamprophyre that crosscuts the whole succession, including the Sunrise shear zone, yield an Ar/Ar plateau age of 2080 ± 4 Ma.

This study constrains the timing of multiple events at Cleo, including the main phase of gold mineralization, during a relatively short span of time. However, in the context of the larger debate about the existence of a dominant 2640 to 2625 Ma period of gold mineralization and the extent of a proposed widespread pre-2660 Ma mineralization event in the Yilgarn craton, the data from Cleo are equivocal, the 2654 ± 8 Ma age for mineralization being significantly older than 2640 Ma but not significantly pre-2660 Ma, even if the maximum possible age is accepted.