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Archaean hydrothermal fluid modified zircons at Sunrise Dam and Kanowna Belle gold deposits, Western Australia: Implications for post-magmatic fluid activity and ore genesis

Rui Wang[1,*,†], Heejin Jeon[2,3], and Noreen J. Evans[4]

[1]State Key Laboratory of Geological Processes and Mineral Resources, and School of Scientific Research, China University of Geosciences, Beijing 100083, China
[2]Centre for Microscopy, Characterisation and Analysis, University of Western Australia, Perth, Western Australia 6009, Australia
[3]Department of Geosciences, Swedish Museum of Natural History, Box 50 007, SE-10405 Stockholm, Sweden
[4]School of Earth and Planetary Sciences, John de Laeter Centre, TIGeR, Curtin University, Perth, Western Australia 6102, Australia

Abstract

To further our knowledge of ore genesis in one of Australia's preeminent ore districts, we have completed a comprehensive geochemical study of ore-related porphyritic intrusions from the Archaean Kanowna Belle and Sunrise Dam gold deposits (both >10 Moz), Eastern Goldfields, Western Australia. Zircon samples (including samples from the newly developed Velvet mine) with ages ranging from 2.8 to 2.2 Ga, were investigated for O-OH isotopic signatures, trace element abundance, and U-Th-Pb compositions to elucidate the nature of the magmatic source and ore-related fluid. These intrusions have similarly high Sr/Y and La/Yb ratios to adakites from the Aleutian and Cook Islands, but lower Mg# values and higher K_2O contents, suggesting they were derived from partial melts in a thickened crust. The modern analogs are post-collisional, high-Sr/Y granitoid porphyries in southern Tibet. Magmatic zircons have intermediate $\delta^{18}O$ values (+5‰ to +6.3‰), and estimated magmatic crystallization temperatures (Ti-in-zircon) in between 660–760 °C. They are interpreted as having crystallized from positive $\delta^{18}O$ magmas during water-fluxed melting of juvenile lower crust. Hydrothermal fluid modified zircons are texturally indistinguishable from magmatic zircons, but their trace element, OH, and isotopic compositions are distinct. The involvement of hydrothermal fluid in zircon growth is evidenced by a negative correlation between OH content and $\delta^{18}O$. In addition, the studied hydrothermal fluid modified zircons are characterized by high La contents, flat rare earth element patterns, weak Ce anomalies, and high Eu/Eu* ratios, suggesting they were related to a high-temperature, Zr-saturated, high-Eu, Cl-rich, and low-pH hydrothermal fluid. Such fluids are common in eastern Yilgarn gold camps.

Keywords: Hydrothermal fluid modified zircon, fluid, OH, O isotope, gold mineralization, Archaean; From Magmas to Ore Deposits