

Zircon Trace-Element Indicators of Magmatic Gold Fertility

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With the aim of identifying trace-element characteristics of zircon that are diagnostic of magmatic fertility for generating gold-rich magmatic-hydrothermal deposits, we have analyzed by LA-ICPMS 1067 zircon grains in intrusions that exsolved gold-ore-forming magmatic-hydrothermal fluids in 12 major deposits, and we compiled published analyses of 1078 zircons in gold-ore-forming intrusions in another 28 major porphyry-, skarn-, high-sulfidation-epithermal, and Carlin-type gold-dominant deposits at Phanerozoic convergent plate margins worldwide. We compared those trace-element compositions of zircons in gold-ore-forming intrusions with 2044 zircon analyses from granitoid intrusions in unmineralized Phanerozoic arc segments and time intervals worldwide. The comparisons show that zircons from gold-ore-forming intrusions tend to have higher U_i/Yb and Nb/Y depending on the metallogenic region. Zircons in gold-ore-forming intrusions have consistently higher ratios of the composite ratio $104 \times (Eu/Eu^*)/YbN + 5 \times Ce/\sqrt{(U_i \times Ti)}$, wherein $(Eu/Eu^*)/YbN$ is an indicator of silicate melt hydration state; $Ce/\sqrt{(U_i \times Ti)}$ measures silicate melt oxidation state in which U_i represents radioactive-decay-corrected initial ppm U at the time that dated zircons crystallized. We applied the zircon $(Eu/Eu^*)/YbN$ hygrometer and $Ce/\sqrt{(U_i \times Ti)}$ oxybarometer to a 6-Myr time series of pre-ore to late-mineralization samples from the Yanacocha igneous complex to track the temporal evolution of melt hydration state and oxidation state. Our results indicate that pre-ore intrusions were less hydrous and less oxidized than ore-stage melts. In orogenic stress regimes, replenished magma chambers residual granitoid melts inherit an accumulation of volatiles and oxidized members of redox couples, which contribute to enhanced Au-Cu metallogenic fertility. Due to the mechanical and chemical robustness of zircon, these discriminants of magmatic gold fertility are applicable to detrital zircons to identify watersheds containing gold-fertile igneous complexes upstream from the sediment sampling site.