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Multiple Metal and Fluid Sources Inferred for the Ernest Henry Iron Oxide Copper Gold (IOCG) Deposit, Queensland, Australia: Insights from Magnetite O, Fe, and Ti Isotopes

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Iron oxide copper gold (IOCG) deposits are an important source of Cu; however, their formation mechanisms remain contentious. We utilized integrated Fe, Ti, and O isotopic data for magnetite to trace metal and fluid sources for the Ernest Henry IOCG deposit—the largest IOCG-style deposit in the Cloncurry District, Queensland, Australia. Magnetite grains from within and near the Ernest Henry deposit were analyzed for their O, Fe, and Ti isotope compositions, which are reported as δ18O, δ56Fe, and δ49Ti. The δ18O values of samples from the ore zone (+2.98‰; 2σ = 3.05‰) and adjacent unmineralized lithologies (+1.65‰; 2σ = 1.25‰) suggest a magmatic-hydrothermal origin for these magnetites; non-magmatic δ18O values > c. 5‰ may be explained through carbonate assimilation or contamination. However, δ56Fe values for the ore zone (-0.14‰; 2σ = 0.58‰) and off-deposit (-0.01‰; 2σ = 0.44‰) magnetites are generally lower than the typical range (c. +0.06 to +0.49‰) for magmatic(-hydrothermal) magnetite, suggesting non-magmatic Fe input. Ore zone magnetite δ49Ti (+1.72‰; 2σ = 2.23‰) compositions exhibit a loose correlation with δ18O (R^2 = 0.52) and are most variable within the ore zone, suggesting that Ti isotope compositions are not as resilient to post-magmatic processes as has been suggested. The data are best explained by invoking multiple fluids including both magmatic and non-magmatic components. The earliest generation of magnetite formed from components inherited from the host rock protolith(s) wherein magmatic(-hydrothermal) O, Fe, and Ti isotopic compositions are preserved. Later fluid flow channeled between the footwall and hanging wall shear zones introduced non-magmatic Fe that may have been leached from local mafic units by magmatic-hydrothermal fluids, resulting in magnetite with magmatic δ18O, but non-magmatic δ56Fe. Our results demonstrate that multiple fluid and metal sources may contribute to the formation of IOCG deposits.