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Genesis of IOA and IOCG Deposits Along the Cordillera de la Costa, Peru: Insights from Iron ($\delta^{56}\text{Fe}$) and Triple Oxygen ($\delta^{18}\text{O}$, $\Delta^{17}\text{O}$) Isotopic Analysis of Magnetite

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Iron oxide-apatite (IOA) and iron oxide-copper-gold (IOCG) deposits represent significant metal resources needed for the green energy transition. However, their genesis and possible relationships between these deposit types remain poorly understood and are a matter of intense debate. The Cordillera de la Costa of southern and central Peru hosts several IOA and IOCG deposits that have been comparatively little studied in a global context, and they may thus be able to provide new insights into the genesis of these enigmatic but economically important ores. We report new iron ($\delta^{56}\text{Fe}$) and triple oxygen ($\delta^{18}\text{O}$, $\Delta^{17}\text{O}$) isotope data for 23 magnetite samples collected from two IOA (Marcona, Hierro Acari) and two IOCG (Mina Justa, Raul-Condestable) deposits in Peru as well as from the nearby Pampa del Pongo iron skarn deposit. Petrographic characterization of magnetite-bearing samples from Mina Justa and Raul-Condestable was also done to provide a textural context for the isotope data. The measured magnetite isotopes ranges are $\delta^{18}\text{O} = 0.17 - 5.30 \text{ ‰}$ and $\delta^{56}\text{Fe} = -0.06 - 0.49 \text{ ‰}$. The values from all five deposits essentially overlap with the ranges determined for ortho-magmatic magnetite, thus indicating a predominantly magmatic origin. Nevertheless, the magnetite $\Delta^{17}\text{O}$ values ($-0.097 - -0.016 \text{ ‰}$) are in part heavier and in part lighter than typical magmatic values. This suggests local alteration by low-temperature fluids and input from evaporites, respectively. Further analysis of our new isotope data will provide new insights into the genesis of and relationships between IOA, IOCG, and iron skarn deposits in Peru. Our insights will assist in the development of novel exploration strategies for these important metal resources in Peru and likely also on a global level.