

Decoupling of Whole-rock and Zircon Fertility Proxies in the Supergiant Llurimagua Porphyry Cu–Mo Deposit, Ecuador

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Llurimagua is a supergiant porphyry Cu–Mo deposit in northwestern Ecuador associated with an igneous suite that records a multi-Myr increase in whole-rock fertility proxies, culminating in peak fertile signatures in ore-related porphyries prior to mineralization. However, zircon trace-element fertility proxies in these porphyries commonly yield barren-like or anomalous signatures, revealing pronounced whole-rock–zircon decoupling. In this context, we investigate the transcrustal magmatic evolution of the fertile Llurimagua intrusive suite to identify the processes responsible for generating false-negative zircon fertility signatures. Using a strict petrologic and petrochronologic approach, our results indicate that zircons from the intrusive suite chiefly record an upper-crustal magmatic evolution of the transcrustal system, and that the barren-like signatures of the ore-related porphyries reflect complex, mush-dominated upper-crustal dynamics. Elevated melt P during the porphyry stage promotes xenotime-type substitution and modifies REE-pattern curvature, thereby influencing parameters such as Dy/Yb and λ_3 . Furthermore, extensive plagioclase fractionation lowers the residual melt Eu budget and leads to barren-like Eu anomalies (<0.36) even under oxidized conditions ($\Delta\text{FMQ} = +0.5$ to $+2.5$). Our results highlight that zircon fertility proxies should be interpreted within a robust petrochronologic and textural framework and, where possible, integrated with whole-rock geochemistry. In this way, zircon can be used to complement our understanding of the transcrustal magmatic system and reduce the risk of false negatives during magma fertility assessment.