

What Sulfur Isotopes Reveal About Ore Formation in the Southwest Yilgarn Craton

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Multiple sulfur isotopes ($\delta^{34}\text{S}$, $\Delta^{33}\text{S}$, $\Delta^{36}\text{S}$) provide critical insights into the evolution and origin of sulfur in mineralizing systems. This study uses in situ secondary ion mass spectrometry (SIMS) to analyse sulfide minerals from 13 mineral deposits across the southwest Yilgarn Craton, Western Australia, encompassing porphyry, volcanic-hosted massive sulfide (VHMS), and granulite-facies gold systems.

Porphyry and several VHMS deposits yield near-zero $\Delta^{33}\text{S}$ values and $\Delta^{36}\text{S}/\Delta^{33}\text{S}$ ratios indicative of mass-dependent fractionation, consistent with a dominantly mantle-derived sulfur source. In contrast, metamorphosed gold systems show broader $\Delta^{33}\text{S}$ ranges (-0.7 to $+1.2\text{‰}$) and mass-independent fractionation signatures, pointing to the involvement of Archean sedimentary sulfur reservoirs. Some deposits are isotopically homogeneous, while others record multiple, compositionally distinct fluid sources within a single mineralizing event.

These results demonstrate the retention of sulfur isotope heterogeneity across deposit types, even in high-grade metamorphic settings. The findings underscore the utility of multiple sulfur isotope analyses for tracing fluid sources, reconstructing ore-forming processes, and distinguishing crustal–mantle interactions in Archean terranes. This study provides a geochemical framework to refine metallogenic models and guide exploration in the southwest Yilgarn Craton.