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Maps to riches: regional-scale sulphur isotope maps of orthomagmatic mineralisation

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Sulphur (S) plays a fundamental role in the formation of orthomagmatic deposits, which are important sources of nickel (Ni), a critical metal for battery technologies essential for the energy transition [1]. Assimilation of S by mantle-derived (mafic to ultramafic) magmas is key for the generation of sulphide liquids that accumulate to form this style of mineralization [2]. At a deposit scale, S isotopes have been used to constrain the source and degree of crustal assimilation, and mixing models predict that the S isotope signature associated with high Ni tenors reflects the $\delta^{34}S$ of the mantle-derived melt (~0‰) [3]. However, these geochemical tools have not been applied on a regional scale.

We used in-situ S isotope analyses of pyrrhotite, chalcopyrite, and pentlandite from 23 variably mineralized intrusions, and metasedimentary pyrrhotite from 47 associated country rock samples, to create regional $\delta^{34}S$ maps of the prospective Proterozoic Fraser Zone in Western Australia. The $\delta^{34}S$ values of intrusive rocks show similar patterns to those of metasediment-hosted pyrrhotite, indicating assimilation was localized to length-scales <10 km. The highest Ni tenors correspond to moderate $\delta^{34}S$ values (1.5‰–2.5‰), and when combined with trace element data, indicate that high tenor sulphides do not form if the amount of crustal assimilation is either too low or too high. We propose that a similar relationship between Ni tenor and $\delta^{34}S$ may exist in prospective regions for orthomagmatic deposits elsewhere, and that regional S isotope mapping can reveal these trends.

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