Sulfur Isotope Systematics of Granitoids from the Yilgarn Craton Shed New Light on the Fluid Reservoirs of Neoarchean Orogenic Gold Deposits

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The identification of the fluid reservoirs of Neoarchean orogenic gold deposits is crucial for understanding the sulfur cycle through the lithosphere and improving exploration strategies to spark new discoveries. Recently, the analysis of Mass-Independent Fractionated Sulfur (MIF-S) isotope signatures of sulfide from gold-bearing assemblages has revealed that (i) at least some of the sulfur in the mineralizing fluids had previously interacted with the Archean oxygen-free atmosphere, and (ii) such fluids were commonly sourced from homogeneous reservoirs at depth. However, the nature and spatial distribution of such reservoirs has so far remained elusive as the lithological and compositional variation of the deep Archean lithosphere remains poorly constrained.

In this study, we focused on the sulfur isotope composition of granitoids, which can represent a proxy for constraining the signature of lower crustal sulfur reservoirs. We analyzed granitoids distributed throughout the Archean Yilgarn Craton of Western Australia, demonstrating that most of them carry MIF-S signatures. In view of recent studies on the genesis of granitoids advocating for magma formation through infra-crustal melting at mid- to lower-crustal regions, MIF-S signatures in granitoids indicate the presence of supracrustal sulfur transported to deep crustal levels and incorporated into the bulk melt sources. Furthermore, the spatial distribution of MIF-S signatures in the granitoids mimics that of Nd and Hf radiogenic isotopes and identifies homogeneous domains that coincide with the current terrane subdivision of the Yilgarn Craton, which reflects cratonic crustal evolution and lithospheric architecture. Because this spatial distribution in MIF-S signatures is also reflected in Neoarchean orogenic gold deposits, it implies a common sulfur reservoir. Therefore, we suggest that the mineralizing fluids exsolved from melts originated through the reworking of deep crustal regions, possibly with the contribution of portions of metasomatized mantle lithosphere.