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No Encore for MIF: Transvaal Quadruple Sulfur Isotope Systematics Demonstrate post-GOE Atmospheric Stability

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Linked through genesis, transport and preservation, the sedimentary loss of mass-independent sulfur isotope fractionation (S-MIF) is widely regarded as the chemostratigraphic fingerprint of the Great Oxidation Event, marking the rise of atmospheric oxygen above ~10^{-5} PAL. Although striking in $\Delta^{33}S$–time compilations, the stratigraphic expression of the S-MIF demise is presently only resolved in the Carletonville area of the Transvaal Basin, South Africa[1]. Here, the collapse of $\Delta^{33}S$ occurs within the c.2.3 Ga Rooihoogte Formation and is commonly interpreted as a one-way atmospheric shift away from a MIF-producing state[1]. Reports of large positive $\Delta^{33}S$ values from the overlying Timeball Hill Formation in cores EBA-1 and -2, however, complicate this framework, contesting the "one-and-done" model in favour of a prolonged, oscillatory delay in permanent atmospheric oxygenation[2]. To discriminate between these models, we extend the Transvaal quadruple sulfur isotope record ~350 km eastward in core ANW-1, where we document another abrupt loss of S-MIF within the Rooihoogte Formation that mirrors the Carletonville demise. This coherent and reproducible collapse across the basin reinforces the significance of this transition. Importantly, in ANW-1, once MIF is lost $\Delta^{33}S$ values remain indistinguishable from zero and no return is observed. To evaluate the clear discrepancy between cores ANW-1 and EBA-1 and-2, we analysed an archived historical EBA-1 sample suite housed at the University of Johannesburg[3] and conducted targeted re-sampling of core EBA-1 designed to capture reported MIF-bearing intervals. Despite deliberate selection of these horizons, we do not reproduce large positive $\Delta^{33}S$ values in the Timeball Hill Formation. Furthermore, we reanalysed all available MIF-bearing powders and hand specimens provided for independent study[2]. While admittedly reanalysis of some of the powders yielded instances of S-MIF, reproducibility is notably core-specific, and several reportedly MIF-bearing powders exhibit mass-dependent QSI systematics. Notably, none of the re-powdered hand specimens yield resolvable S-MIF. Taken together, *no* reproducible stratigraphic or material evidence supports renewed MIF production after its Rooihoogte-recorded loss. Apparently, once the atmospheric threshold observed in the Rooihoogte Formation was crossed, it was not revisited, leaving no encore for MIF.

[1]Luo et al. (2016) Science Advances; [2]Poulton et al. (2021) Nature. [3]Coetzee (2001) RAU.