The Great Oxidation Event preceded a Paleoproterozoic 'snowball Earth'

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The temporal relationship between the Great Oxidation Event (GOE) and a Paleoproterozoic 'snowball Earth' glaciation remains unresolved. We present new, temporally constrained, quadruple sulfur isotope measurements ($\delta^{34}S$, $\Delta^{33}S$ and $\Delta^{36}S$) from the Paleoproterozoic Seidorechka and Polisarka Sedimentary Formations in NW Russia. The older Seidorechka Sedimentary Formation preserves negative $\Delta^{33}S$ values and a $\Delta^{36}S/\Delta^{33}S$ slope of -1.86 ± 0.47, consistent with Archean values. The younger Polisarka Sedimentary Formation preserves mass-dependent signals, with a $\Delta^{36}S/\Delta^{33}S$ slope of -8.8 and negative $\delta^{34}S$ values. The transition from mass-independent (S-MIF) to mass-dependent fractionation of S isotopes (S-MDF) is bracketed by established radiometric ages of 2501.5 ± 1.7 Ma and 2434 ± 6.6 Ma. Thus, the S-MIF/S-MDF transition predates both the Polisarka glacial deposits and the ~2424 Ma Makganyene 'snowball Earth' diamictite in South Africa, supporting the hypothesis that atmospheric oxygenation caused the collapse of a methane-dominated greenhouse and triggered global glaciation.