Globally asynchronous sulfur isotope signals require re-definition of the Great Oxidation Event

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Earth's Great Oxidation Event (GOE) occurred when enough free oxygen accumulated to prevent the preservation, in sedimentary rocks, of mass-independent fractionation of sulfur isotopes (MIF-S) sometime between 2.45 and 2.2 billion years (Ga) ago. However, expectations that the GOE was rapid and globally synchronous are confounded by correlations that place the GOE 50–100 million years (Ma) later in South Africa than in North America. To address this timing problem, here we apply multiple sulfur isotopes and Re-Os dating of sulfides to a continuous sedimentary sequence from Western Australia that spans the GOE. Our data indicate that starting at ~2.45 Ga, the prolonged deposition of MIF-S sulfide until about 2.25 Ga was punctuated by several episodes of MIF-S disappearance. This is consistent with deposition under oxic conditions, where the absence of MIF-S signal reflects the contribution of sulfate aerosols produced in an oxic atmosphere, and the low amplitude of MIF-S represents sulfate derived from oxic weathering of continental sulfides carrying a MIF-S anomaly. A low residence time for oceanic sulfate from mixed sources would thus explain the asynchronous record of MIF-S among different basins, and draws into question the paradigm of using the MIF-S record to attribute a singular and global age to the GOE.