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The Paleoproterozoic Snowball Earth: A climate disaster triggered by the evolution of oxygenic photosynthesis.

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Abstract: The rise of oxygenic photosynthesis and the oxygenation of the atmosphere are two of the most important events in Earth history. A preponderance of evidence now supports the hypothesis that planetary oxygenation occurred between ca. 2.5 and 2.2 Ga. While biomarker, trace element, and isotopic evidence have been used to claim that oxygenic photosynthesis evolved by 2.8 Ga and perhaps as early as 3.8 Ga, a skeptical examination raises considerable doubt about how strongly this earlier evidence actually demands the presence of oxygen. The occurrence of numerous geological oxygen indicators immediately before and after the Paleoproterozoic Makganyene Snowball Earth at ca. 2.3-2.2 Ga supports an alternate history, in which the evolution of oxygenic photosynthesis triggered the geologically rapid destruction of a methane greenhouse and Earth's first global glaciation. New age constraints from the Transvaal Supergroup in South Africa demonstrate that all three of the Huronian glaciations in Canada predate the oxygenation and Snowball event. A simple growth model incorporating the range of C, Fe, and P fluxes expected during the Huronian glacial episode indicates cyanobacteria could have destroyed a methane greenhouse and triggered the Paleoproterozoic Snowball Earth on timescales as short as 1 My. As the geological expression of oxygen does not appear during the Pongola glaciation at 2.9 Ga or in the earlier part of the Huronian interval, when these fluxes should also have been high, we argue oxygenic cyanobacteria evolved and radiated shortly before the Makganyene Snowball.