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Earth's Descent into 'Snowball Earth': Fire and Ice revisited

ELIAS J RUGEN[1], FRED T BOWYER[2], BENJAMIN J. W. MILLS[2], ISAAC JAMES ONYETT[3], LIN YUAN[1], THOMAS M GERNON[4], ANDREW S. MERDITH[5], IAN J FAIRCHILD[6], ANTHONY SPENCER[7], XI CHEN[1], GUILLAUME LE HIR[8], YING ZHOU[9] AND GRAHAM A. SHIELDS[1]

[1]University College London
[2]University of Leeds
[3]Centre for Star and Planet Formation, Globe Institute, University of Copenhagen
[4]University of Southampton
[5]The University of Adelaide
[6]University of Birmingham
[7]N/A
[8]Université de Paris
[9]Johannes Gutenberg-Universität

The 'Fire and Ice' hypothesis proposes a mechanistic link between the initiation of the 717 Ma 'Sturtian' Snowball Earth glaciation and the emplacement of the Franklin Large Igneous Province (LIP), a vast outpouring of basalt that peaked 1–2 Myrs prior to glacial onset. The emplacement and subsequent weathering of the Franklin LIP could have triggered planetary cooling via two primary mechanisms: (1) drawdown of atmospheric CO_2 into sedimentary carbonate rock due to rapid chemical weathering of freshly extruded basalt; and (2) drawdown of atmospheric CO_2 into sedimentary organic carbon due to nutrient release and enhanced primary productivity at ocean margins. The geological record of Earth's descent into Snowball Earth has been widely erased by the effects of glacial erosion, rendering many hypotheses untestable through direct evidence. The Garvellach Islands, SW Scotland, represent a rare exception whereby shallow marine carbonates of the latest Tonian Period transition directly into glacial deposits of the Cryogenian, with minimal to no hiatus. Here, we investigate the final stages leading into the 'Sturtian' glaciation by examining key perturbations to the carbon cycle and silicate weathering thermostat using carbon ($d^{13}C$) and strontium ($^{87}Sr/^{86}Sr$) isotopes, respectively. By integrating new high resolution geochemical data from the Garvellach Islands into a late Tonian age model, we observe a marked global decrease in seawater $^{87}Sr/^{86}Sr$ of 0.004–0.016, along with an increase in $d^{13}C$ of +6‰, following emplacement of the Franklin LIP. Using the SCION Earth System model, we show that the weathering of such a vast volume of basalt in an elevated region near the equator may have been enough to drive one of the most extreme climatic shifts in Earth history.