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Running out of gas: Zircon ^{18}O-Hf-U/Pb evidence for Snowball Earth preconditioned by low degassing

Jens Hartmann (1), Gaojun Li (2), and A. Joshua West (3)

(1) Institute for Geology, Center for Earth System Research and Sustainability (CEN), Universität Hamburg, Bundesstrasse 55, D-20146 Hamburg, Germany (geo@hattes.de), (2) MOE Key Laboratory of Surficial Geochemistry, Department of Earth Sciences, Nanjing University, 163 Xianlindadao, Nanjing 210023, China (ligaojun@nju.edu.cn), (3) Department of Earth Sciences, University of Southern California, 3651 Trousdale Parkway, Los Angeles, CA 90089, USA (joshwest@usc.edu)

The general long-term stability of Earth's climate over geologic time was punctuated by dramatic excursions. Between ca. 2.5 billion years (Ga) and 0.5 Ga ago, these events included the globally extensive glaciations known as Snowball Earths, when ice extended to tropical latitudes. Such anomalous periods of time provide unique opportunities for understanding the mechanisms regulating planetary climate and habitability. However, the causes of these events remain enigmatic, in part because there is little information about fluxes in the global carbon cycle in deep time. We propose that the oxygen stable isotope composition in zircons ($\delta^{18}O_{zircon}$) contains information about past weathering conditions on the continents, imparted during the time between separation of parent material from the mantle (reflected in the Hf model age) and zircon crystallisation (the U/Pb age). A new compilation of coupled ^{18}O-Hf-U/Pb isotopic data shows that the mean $\delta^{18}O_{zircon}$ value varied particularly between 2.5 Ga and 0.5 Ga. The maximum in the $\delta^{18}O_{zircon}$ record, which we interpret as a time of intense weathering, is associated with the Lomagundi Event ($\sim$2.22–2.07 Ga), a dramatic carbon isotope excursion thought to reflect enhanced organic carbon burial facilitated by the release of phosphorous during rock weathering. The onset of the Neoproterozoic Snowball Earth coincides with the minimum in $\delta^{18}O_{zircon}$, suggesting low silicate weathering rates at the time. This evidence suggests that long-term decreases in the rate of CO_2 release to the atmosphere from solid Earth degassing may have preconditioned the global climate system for intense glaciations.

Reference:

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