

## Ice or fire? Constraining the origin of isotopically anomalous cap carbonate cements by SIMS

Cui, Huan; Orland, Ian J.; Denny, Adam; Kitajima, Kouki; Fournelle, John H.; Baele, Jean-Marc; De Winter, Niels; Goderis, Steven; Claeys, Philippe; Valley, John W.

*Published in:*

Geological Society of America Abstracts with Programs. Vol. 51, No. 5

*DOI:*

[10.1130/abs/2019AM-332456](https://doi.org/10.1130/abs/2019AM-332456)

*Publication date:*

2019

[Link to publication](#)

*Citation for published version (APA):*

Cui, H., Orland, I. J., Denny, A., Kitajima, K., Fournelle, J. H., Baele, J.-M., ... Valley, J. W. (2019). Ice or fire? Constraining the origin of isotopically anomalous cap carbonate cements by SIMS. In Geological Society of America Abstracts with Programs. Vol. 51, No. 5 (Vol. 51, pp. 1-1). Denver Co.: Geological Society of America. <https://doi.org/10.1130/abs/2019AM-332456>

### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

### Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

**ICE OR FIRE? CONSTRAINING THE ORIGIN OF ISOTOPICALLY ANOMALOUS CAP CARBONATE CEMENTS BY SIMS**

**CUI, Huan**<sup>1</sup>, ORLAND, Ian J.<sup>2</sup>, DENNY, Adam<sup>2</sup>, KITAJIMA, Kouki<sup>3</sup>, FOURNELLE, John H.<sup>4</sup>, BAELE, Jean-Marc<sup>5</sup>, DE WINTER, Niels J.<sup>6</sup>, GODERIS, Steven<sup>7</sup>, CLAEYS, Philippe<sup>7</sup> and VALLEY, John W.<sup>8</sup>, (1)NASA Astrobiology Institute & WiscSIMS, Department of Geoscience, University of Wisconsin, Madison, WI 53706; Research Group of Analytical, Environmental, and Geo- Chemistry, Division of Earth System Science, Vrije Universiteit Brussel, Brussels, 1050, Belgium; ET-HOME (Evolution and Tracers of the Habitability of Mars and Earth) Astrobiology Research Consortium, Brussels, 1050, Belgium, (2)WiscSIMS, Department of Geoscience, University of Wisconsin, Madison, WI 53706, (3)NASA Astrobiology Institute & WiscSIMS, Department of Geoscience, University of Wisconsin, Madison, WI 53706, (4)Department of Geoscience, University of Wisconsin, Madison, WI 53706, (5)Department of Geology, Faculty of Engineering, University of Mons, Mons, 7000, Belgium, (6)Research Group of Analytical, Environmental, and Geo- Chemistry, Division of Earth System Science, Vrije Universiteit Brussel, Brussels, 1050, Belgium, (7)Research Group of Analytical, Environmental, and Geo- Chemistry, Division of Earth System Science, Vrije Universiteit Brussel, Brussels, 1050, Belgium; ET-HOME (Evolution and Tracers of the Habitability of Mars and Earth) Astrobiology Research Consortium, Brussels, 1050, Belgium, (8)Department of Geoscience, University of Wisconsin-Madison, 1215 W Dayton Street, Madison, WI 53706

The Marinoan glaciation (a.k.a. the Snowball Earth) represents a profound paleoclimatic anomaly in deep time. However, the detailed mechanism of its termination remains largely unknown. It was hypothesized that massive releases of methane via clathrate destabilization at ~635 Ma may have played a role in terminating the glaciation. A key piece of supporting evidence is the finding of methane-derived authigenic calcite cements (MDACCs,  $\delta^{13}\text{C}_{\text{carb}}$  values down to  $-48\text{‰}$ ) within the Marinoan cap carbonates in South China. However, a more recent study based on clumped isotope ( $\Delta_{47}$ ) measurements suggests that the MDACCs are hydrothermal (T as high as 476 °C) in origin. If correct, the MDACCs cannot be used to infer paleoenvironments right after the glaciation. To test these contrasting hypotheses (ice vs. fire), we conducted a detailed investigation via  $\mu\text{XRF}$ , CL, SEM, and SIMS. The SIMS data show a 60‰ range of  $\delta^{13}\text{C}_{\text{carb}}$  values with positive values (as high as  $+6.3\text{‰}$ ) exclusively in dolomites and negative values (as low as  $-53.8\text{‰}$ ) in calcites. Both the positive  $\delta^{13}\text{C}_{\text{carb}}$  values and the lowest  $\delta^{13}\text{C}_{\text{carb}}$  values are revealed in this study for the first time. Our results show that the dolomite crystals are typically euhedral, anomalously large (up to 200  $\mu\text{m}$ ) in size, have positive  $\delta^{13}\text{C}_{\text{carb}}$  values, and are Mn-poor with dull or red luminescence under CL, with dolomite cores partly or almost completely replaced by low- $\delta^{13}\text{C}_{\text{carb}}$  calcite. The calcites have low  $\delta^{13}\text{C}_{\text{carb}}$  values, are Mn-rich with bright orange luminescence under CL, showing multiple stages of vug-filling cements surrounding the preexisting dolomite crystals. These results suggest that the dolomites have been significantly recrystallized during burial or hydrothermal diagenesis and the MDACCs formed even later, postdating the recrystallized dolomites. We conclude that the MDACCs are post-depositional and formed during late diagenesis. Our conclusion is consistent with the prior work based on clumped isotope analysis. The present study casts further doubt on using MDACCs as evidence for methane clathrate in deep time. The role of methane in terminating the Snowball Earth should be re-assessed.

Session No. 293

T81. Hello (Ancient) World!: Exploring the Neoproterozoic to Cambrian Interval by Quantitatively Probing the Rock Record

*Wednesday, 25 September 2019: 1:30 PM-5:30 PM**Room 226ABC, North Building (Phoenix Convention Center)*Geological Society of America *Abstracts with Programs*. Vol. 51, No. 5

DOI: 10.1130/abs/2019AM-332456