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Sulfur and fluorine degassing from Deccan Traps lavas inferred from pyroxene chemistry: potential for end-Cretaceous volcanic winters

Sara Callegaro[1], Don R. Baker[2], Paul R. Renne[3,4], Leone Melluso[5], Kalotina Geraki[6], Martin J. Whitehouse[7], Angelo De Min[8], and Andrea Marzoli[9]

[1]Centre for Planetary Habitability, University of Oslo, Oslo, NO.
[2]Department of Earth and Planetary Sciences, McGill University, Montreal, QC, CA.
[3]Berkeley Geochronology Center, Berkeley, CA, USA.
[4]Department of Earth and Planetary Science, University of California, Berkeley, CA, USA.
[5]DI.S.T.A.R., University of Napoli Federico II, Napoli, IT.
[6]Diamond Light Source, Harwell Science and Innovation Campus, Didcot, UK.
[7]Swedish Museum of Natural History, Stockholm, SE.
[8]Department of Mathematics and Geoscience, University of Trieste, Trieste, IT.
[9]Dipartimento Territorio e Sistemi Agro-Forestali, University of Padova, Legnaro, IT.

The Cretaceous-Paleogene (K-Pg) mass extinction was a pivotal event in Earth's history and is attributed to the interplay of two major events—the Deccan Traps volcanism and the Chicxulub asteroid impact. We contribute to refine of our understanding of the volcanic stressor for this extinction by investigating the sulfur and fluorine budgets of Deccan lavas from the Western Ghats (India), spanning the K-Pg boundary [1].

Sulfur and fluorine concentrations were analyzed in clinopyroxene phenocrysts from Deccan Traps lavas, by Synchrotron-light X-ray fluorescence (beamline I18, Diamond Light Source, U.K.), and ion probe (CAMECA IMS 1280 at Nordsim Laboratory, Swedish Museum of Natural History, Stockholm, SE), respectively. The results were divided by experimentally determined partition coefficients to calculate melt concentrations.

Our analyses reveal variable magmatic volcanic fluorine concentrations ranging from 400 to 3000 parts per million, suggesting the potential for regional environmental impact. The highest sulfur concentrations, reaching up to 1800 parts per million, are observed in Deccan lavas emplaced just prior to the extinction interval, within a timeframe of 0.1 million years. In contrast, later basalts generally exhibit lower sulfur concentrations, only up to 750 parts per million.

Independent evidence [2] supports that eruption of the Deccan flood basalts occurred in multiple voluminous eruptive pulses each lasting on the order of centuries, as typical of continental flood basalts. Our findings propose that the volcanic sulfur degassing associated with such activity may have led to repeated, short-lived global temperature drops, too short to be recorded by global paleotemperature record, albeit coupled with a global cooling trend. Sulfur-induced cold snaps

likely imposed stress on ecosystems long before the decisive impact of the Chicxulub bolide at the end of the Cretaceous.

[1] Sara Callegaro, et al., (2023) Recurring volcanic winters during the latest Cretaceous: Sulfur and fluorine budgets of Deccan Traps lavas. Sci. Adv. 9, eadg8284 doi:10.1126/sciadv.adg8284.

[2] I. M. Fendley, et al., 2019. Constraints on the volume and rate of Deccan Traps flood basalt eruptions using a combination of high-resolution terrestrial mercury records and geochemical box models. Earth Planet Sci Lett. (524) 115721.