Exploring the Toba Eruption: Impacts on Biological Productivity and Global Climate Dynamics

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Volcanic ash layers impact Earth's environment and climate. Our study examines their effects on carbon, cadmium, and sulfur content in deep-sea sediment. We focus on the Toba super eruption (~74,000 years ago), the largest Quaternary explosive eruption, which released ~2,800 cubic kilometers of material. The eruption's sulfur dioxide formed sulfate aerosols, reflecting sunlight and perhaps causing a volcanic winter. Locally high magnetic susceptibility in core RC14-37 indicates a 15 cm thick Toba ash layer at 100-115 cm depth, with the highest ash concentration at 102-104 cm. Sulfur signal dilution by ash is pronounced at 102-106 cm, potentially lowering peak sulfur values. Elevated sulfur just below the top suggests rapid deposition after most ash settled, decreasing towards the base, implying increased atmospheric sulfur at the top. We used X-ray fluorescence (XRF) to measure sulfur and cadmium contents above, within, and below the ash layer. High cadmium concentrations in the ash layers suggest enhanced marine productivity. The SiO_2 contents in the ash are variable (66%-78%) with no clear patterns versus depth. Because the Toba ash contains 12 ppm S [1], we find that the range of bulk S contents in the Toba ash layer (1700 ppm to 3100 ppm) corrected for dilution by carbonate is much too high for most of the S to come from the ash. Instead, most of the S comes from seawater or most likely from sulfate aerosols that settled out of the atmosphere. Our results suggest increased biological productivity and sulfur in ash layers especially near the top of the layers, providing insights into ecological and biogeochemical impacts. Because estimates of the overall amount of sulfur emitted by the Toba eruption range from 1800 ppm to 3600 ppm, our data can help to constrain the true amount of S emitted. Current oxygen isotope data analysis on benthic foraminifera and carbon isotopic analysis on pelagic foraminifera will further refine dating and environmental interpretations.

[1]. Black et al., 2021. Global climate disruption and regional climate shelters after the Toba super-eruption. *Proceedings of the National Academy of Sciences*, *118*(29), p.e2013046118.