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Toba volcano super eruption destroyed the ozone layer and caused a human population bottleneck

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Volcanic eruptions trigger a broad spectrum of climatic responses. For example, the Mount Pinatubo eruption in 1991 forced an El Niño and global cooling, and the Tambora eruption in 1815 caused the "Year Without a Summer." Especially grand eruptions such as Toba around 74,000 years ago can push the Earth's climate into a volcanic winter state, significantly lowering the surface temperature and precipitation globally. Here we present a new, previously overlooked element of the volcanic effects spectrum: the radiative mechanism of stratospheric ozone depletion. We found that the volcanic plume of Toba enhanced the UV optical depth and suppressed the primary formation of stratospheric ozone from O_2 photolysis. Sulfate aerosols additionally reflect the photons needed to break the O_2 bond ($\lambda < 242$ nm), otherwise controlled by ozone absorption and Rayleigh scattering alone during volcanically quiescent conditions. Our NASA GISS ModelE simulations of the Toba eruption reveal up to 50% global ozone loss due to the overall photochemistry perturbations of the sulfate aerosols. We also consider and quantify the radiative effects of SO_2, which partially compensated for the ozone loss by inhibiting the photolytic O_3 sink.

Our analysis shows that the magnitude of the ozone loss and UV-induced health-hazardous effects after the Toba eruption are similar to those in the aftermath of a potential nuclear conflict. These findings suggest a “Toba ozone catastrophe" as a likely contributor to the historic population decline in this period, consistent with a genetic bottleneck in human evolution.