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Evaluation of the role of volatiles in the Youngest Toba Tuff super-eruption

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Volatiles play an important role in the accumulation, evolution, and evacuation of the large silicic magma chamber feeding the super-eruptions. However, the triggering mechanisms of super-eruptions remain controversial. In this study, we apply a conductive-advective thermal model combined with physical mechanisms of water transfer to investigate the construction and long-term evolution of the silicic magma system feeding the Youngest Toba Tuff (YTT) super-eruption (~75,000 years ago) of the Toba volcanic system, Indonesia, based on previous petrological, geochemical, and mineralogical constraints. Our results show that overpressure from the increased volume of exsolved water during the magma cooling plays a subordinate role in the triggering mechanism of the YTT super-eruption. Instead, buoyancy-driven pressure from the water-rich layers accumulating at the top of the magma reservoir could rupture the chamber wall, lowering the overpressure needed for super-eruption. After prolonged continuous magma injection, the progressive accumulation of water-rich magmas generates sufficient buoyancy to finally trigger the YTT super-eruption. This study provides new insights into the role of volatiles in super-eruption dynamics and the long-term evolution of large-scale silicic magma systems.