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Growth and thermal maturation of the Toba magma reservoir

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The Toba volcanic system in Indonesia has produced two of the largest eruptions (>2000 km^3 DRE each) on Earth since the Quaternary. U-Pb crystallization ages of zircon span a period of ~600 ky before each eruptive event and in the run-up to each eruption the mean and variance of the zircons' U content decrease. To quantify the process of accumulation of eruptible magma underneath the Toba caldera, we integrated these observations with thermal and geochemical modeling. We show that caldera-forming eruptions at Toba are the result of progressive thermal maturation of the upper crustal magma reservoir, which grows and chemically homogenizes, by sustained magma influx at average volumetric rates between 0.008 and 0.01 km^3/y over the past 2.2 Myr. Protracted thermal pulses related to magma recharge events prime the system for eruption, without necessarily requiring an increased magma recharge rate before the two super-eruptions. If the rate of magma input was maintained since the last super-eruption of Toba at 75 ka, eruptible magma is currently accumulating at a minimum rate of ~4.2 km^3 per millennium, and the current estimate of the total volume of potentially eruptible magma available today is a minimum of ~315 km^3. Our approach to evaluate magma flux and rate of eruptible magma accumulation is applicable to other volcanic systems capable of producing super-eruptions, and thereby could help assessing the potential of active volcanic systems to feed super-eruptions.