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Zircon record for prolonged magma chamber processes before the Quaternary Toba super-eruption

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The enormous amount of eruptible magmas and the time intervals between large volumes of major eruptions suggest that magmas may need a significant period of time ($\sim$ a million years) to accumulate before a supereruption. However, radiometric ages show that the resident time of a magma reservoir is significantly shorter. This study, for the first time, used in situ zircon U-Pb dating and Hf-O isotopes to decipher Toba magma chamber processes, which gave birth to the largest Quaternary eruption on Earth. Besides the well-recognized four eruptions in Pleistocene, magmatic activities of Toba magma chamber can be traced back to 10.5 Ma, followed by infrequent magma intrusion at 5.2 Ma. Age spectrum of zircon indicates that the volume of eruptions correspond to time of magma storage and evolution. The Youngest Toba Tuff (YTT), in particular, record $\sim$ 450,000 years of crystal accumulation in the upper crustal magma chamber before eruption. Such long periods of magma chamber processes were unlikely to be sustained directly by recharge of voluminous basaltic magmas in terms of zircon Hf-O isotopes, but were probably maintained by periodic influx of fluids and silicic magmas melted in depth. Fractional crystallization and accumulation of crystal mush during this interval help to increase the viscosity of the magma and therefore trap the fluids beneath the chamber roof until triggered for explosive eruptions.