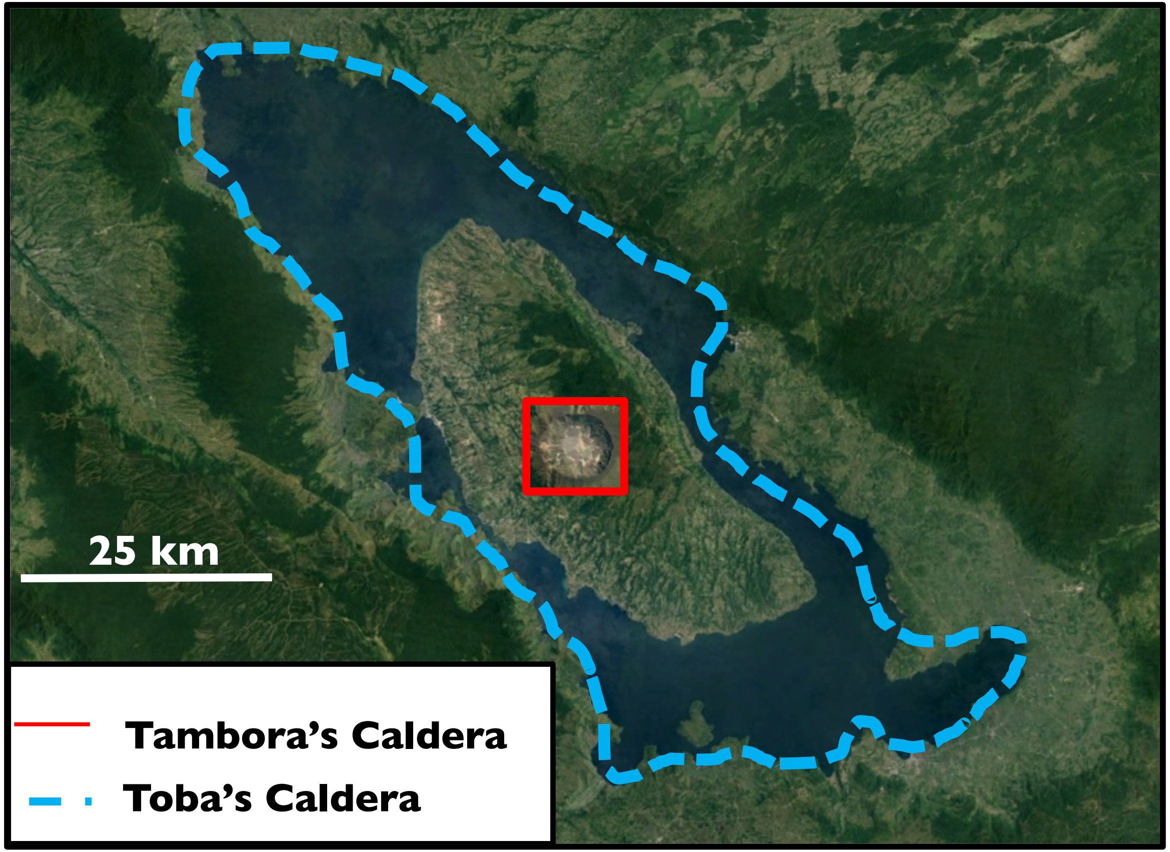
EGU 2020

Where is the Toba eruption in the Vostok ice core? Clues from the O and S isotopes

Savarino[1], J. Gautier[1], E. Caillon[1], N. Hattori[2], S. Albalat[3] E. Albarède[3] F. Petit[1] J-R. Lipenkov[4], V.

1: IGE, Grenoble France,2: TIT, Tokyo, Japan, 3: ENS-Lyon, France, 4: AARI St Petersburg, Russia

Caldera size Tambora vs Toba



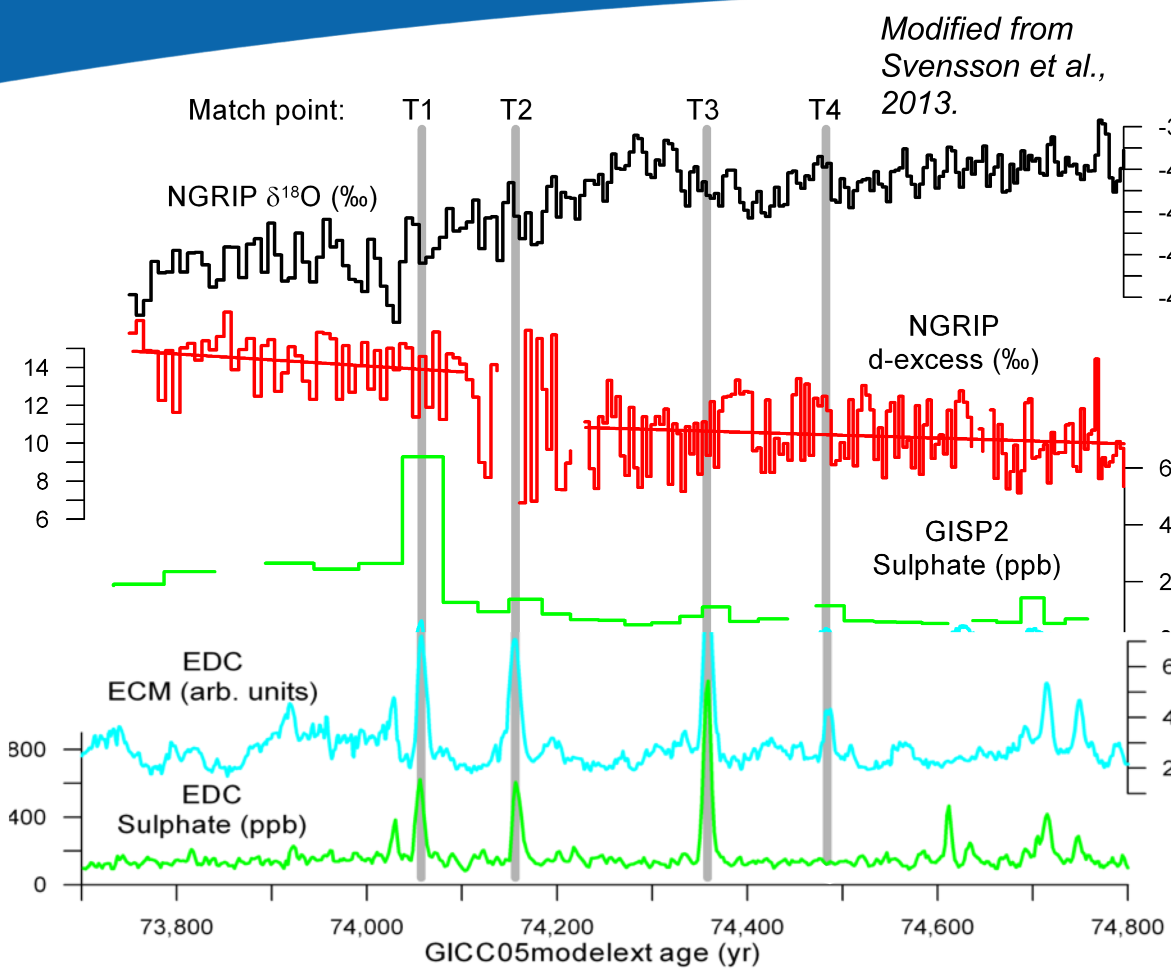
CC BY

	Tambora (Stothers, 1984, Self et al. 2004, Sigl et al., 2015)	**Toba** (Robock et al. 2009, Timmreck et al. 2010, William, 2012, Smith et al. 2018)
Year of eruption	1816	≈ 74 ka
Caldera size	100 km^2	3 000 km^2
Dense Rock Equi.	33 km^3	2 500 – 3 000 km^3
Ash distance	550 km	9 000 km
Sulfur emitted	27-29 Tg	35 – 850 Tg
Cooling forcing	17 W m^{-2}	18 – 100 W m^{-2}
Global temp. drop	1.0 to 1.5 ˚C	3 to 17 ˚C
Highlight	The year without summer	MIS 4-5, Population bottleneck,

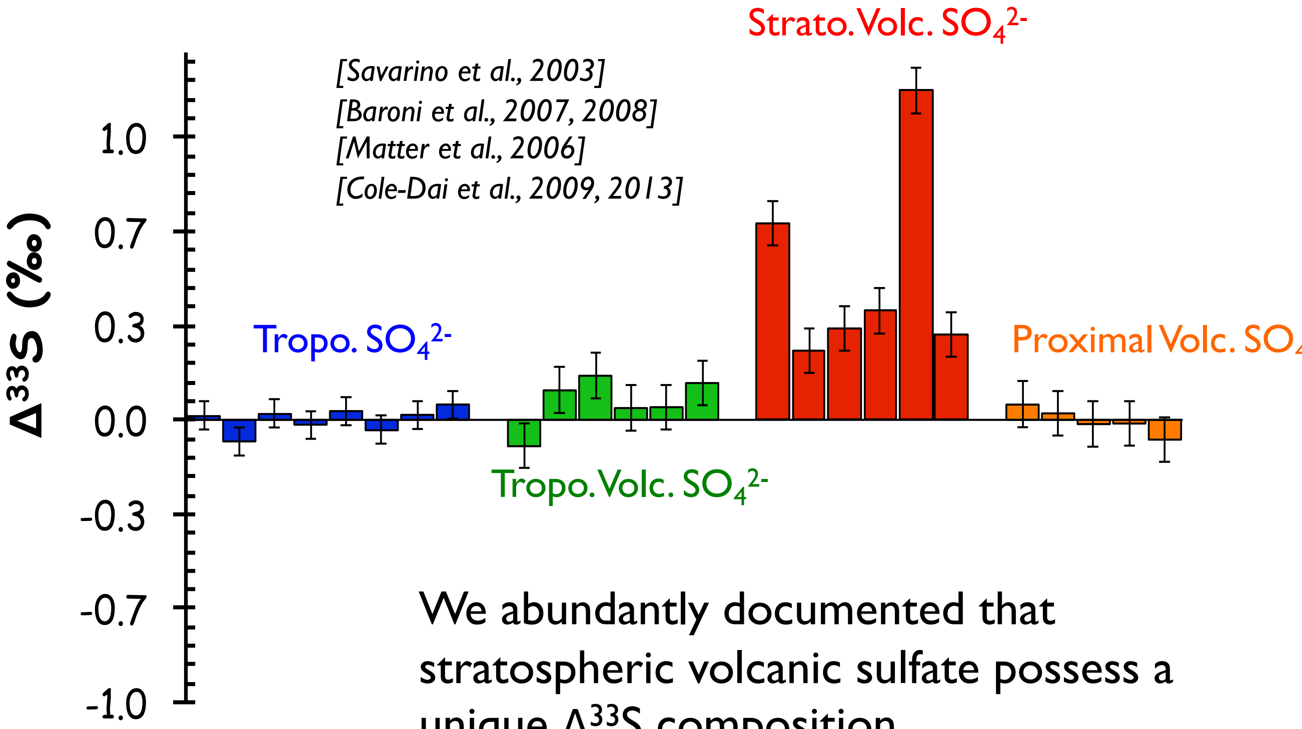
No doubt Toba was a massive eruption, still dynamics and characteristics of the eruption remain largely unknown

CC BY

Based on bipolar comparison, four possible sulfate peaks in ice cores for the Toba has been reported



We used the $\Delta^{33}S$ proxy to verify that these sulfate peaks are at least of stratospheric origin as it should be for mega-eruptions



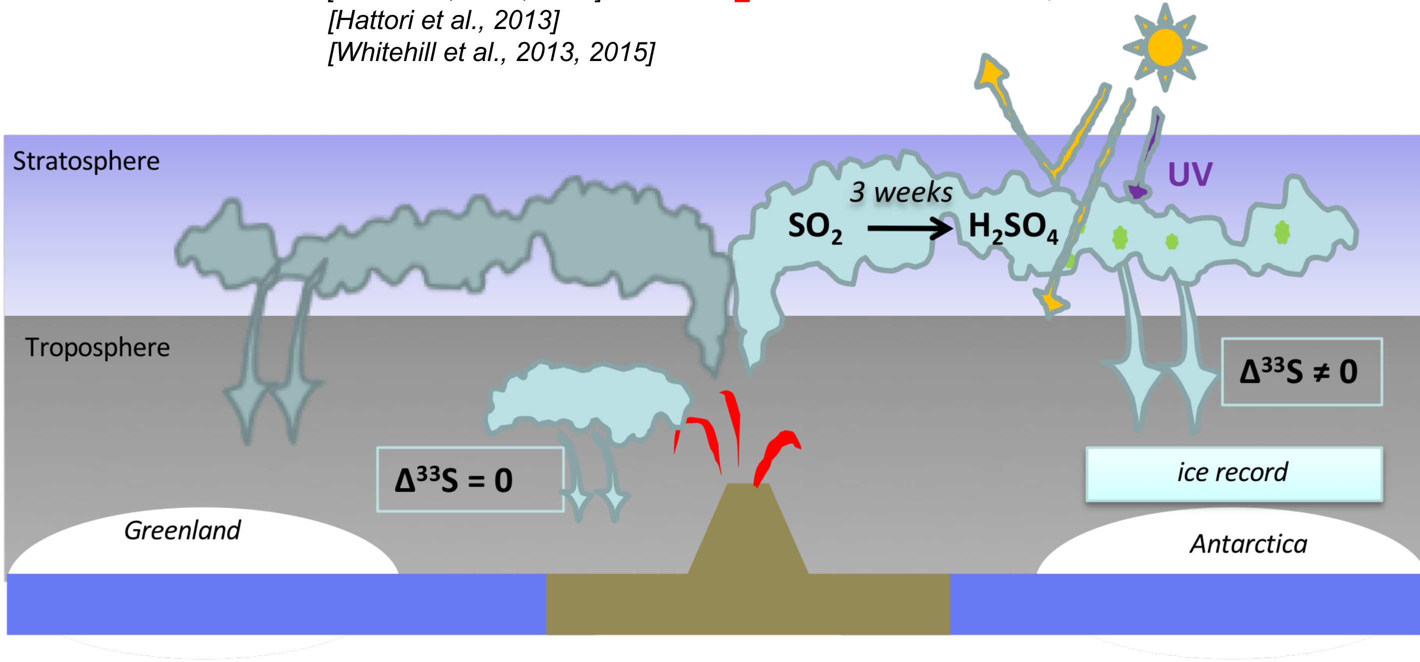
We abundantly documented that stratospheric volcanic sulfate possess a unique $\Delta^{33}S$ composition

CC BY

Mechanism to generate a non-zero $\Delta^{33}S$

[Farquhar et al., 2001]
[Ono et al., 2013, 2008]
[Hattori et al., 2013]
[Whitehill et al., 2013, 2015]

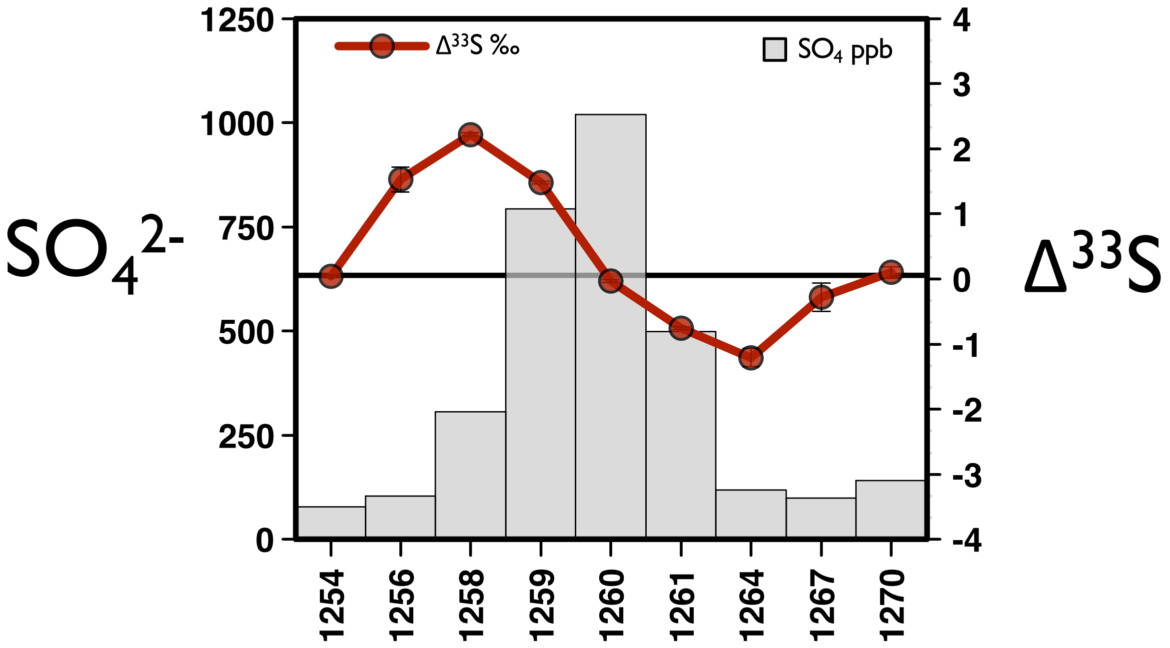
SO_2 + UV ➞ $\Delta^{33}S$, $\Delta^{36}S$



$\Delta^{33}S$ tracer: ➞ independent any chronology
➞ independent any location
➞ independent of deposition flux

CC BY

Typical $\Delta^{33}S$ imprint in ice for stratospheric eruptions



CC BY

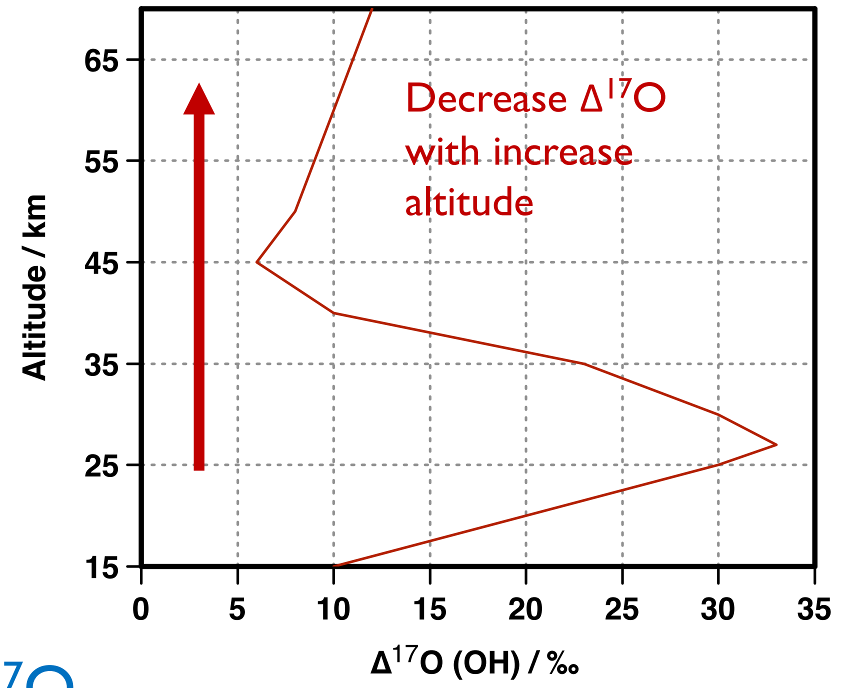
We also used the $\Delta^{17}O$ of sulfate as a qualitative proxy of altitude injection

Main oxidation pathway in the stratosphere

$$SO_2 + OH \rightarrow H_2SO_4$$

- 1 from OH
- 3 from O_2/H_2O

Zahn et al., 2008

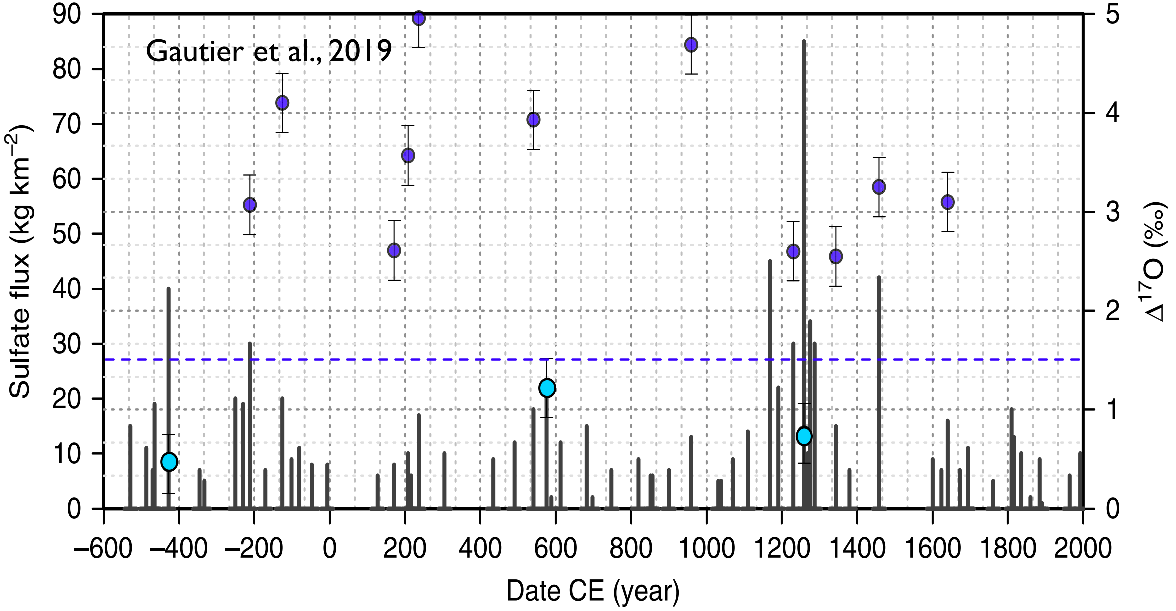


High altitude eruptions have low $\Delta^{17}O$

BY

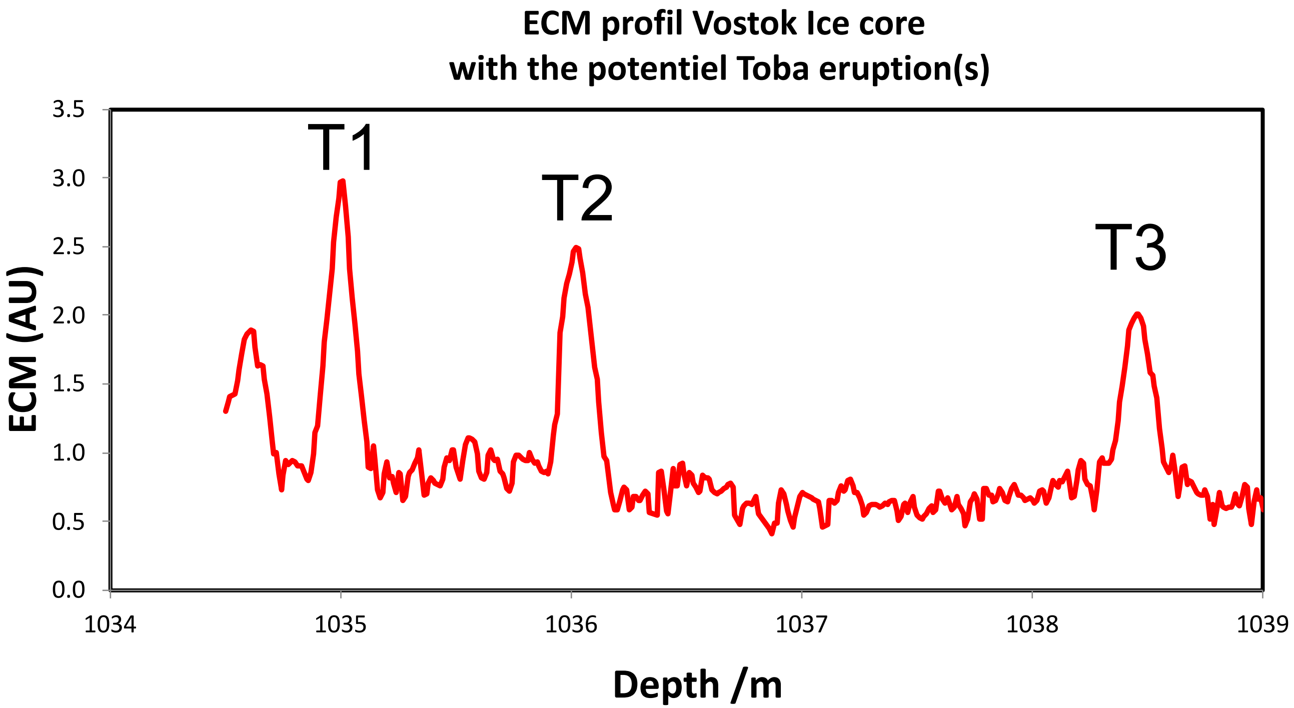
Volcanic Δ¹⁷O

Large eruptions: 1259 CE, 575 CE, 426 BCE have low $\Delta^{17}O$



CC BY

We have identified in the Vostok ice core, three of the potential Toba sulfate peak

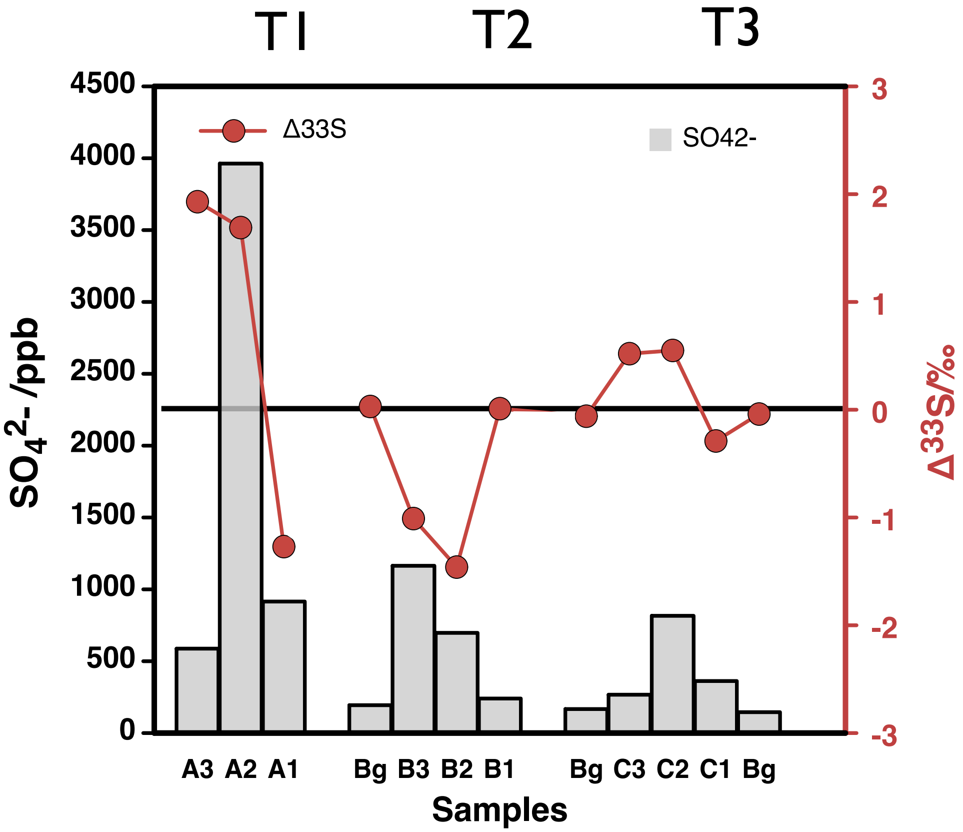


CC BY

$\Delta^{33}S$ of the proposed Toba's layers

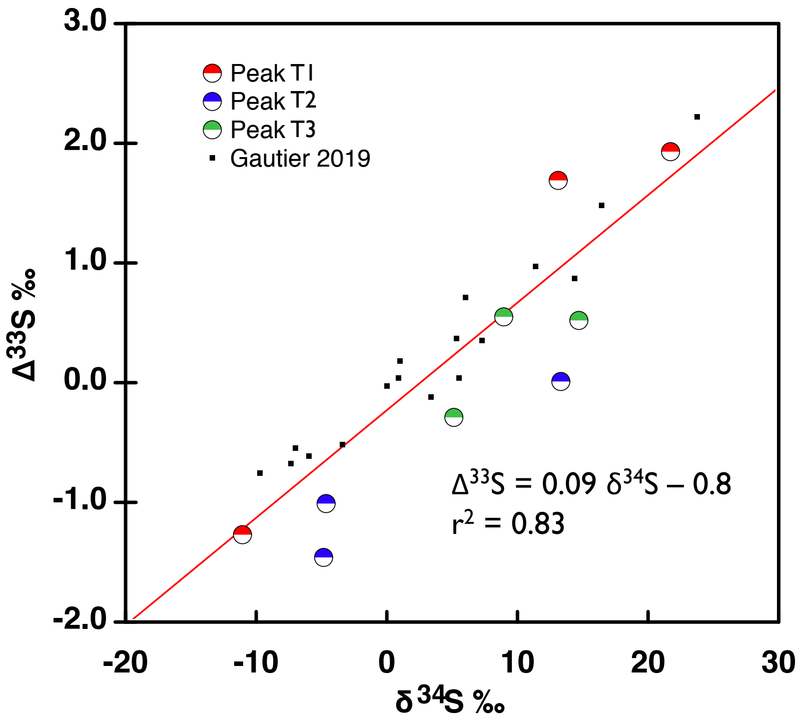
All three eruptions are clearly stratospheric

Peak B preserved only ⊖ phase



CC BY

The sulfur isotopic composition of the T1, T2, T3 eruptions is indistinguishable from previous stratospheric eruptions

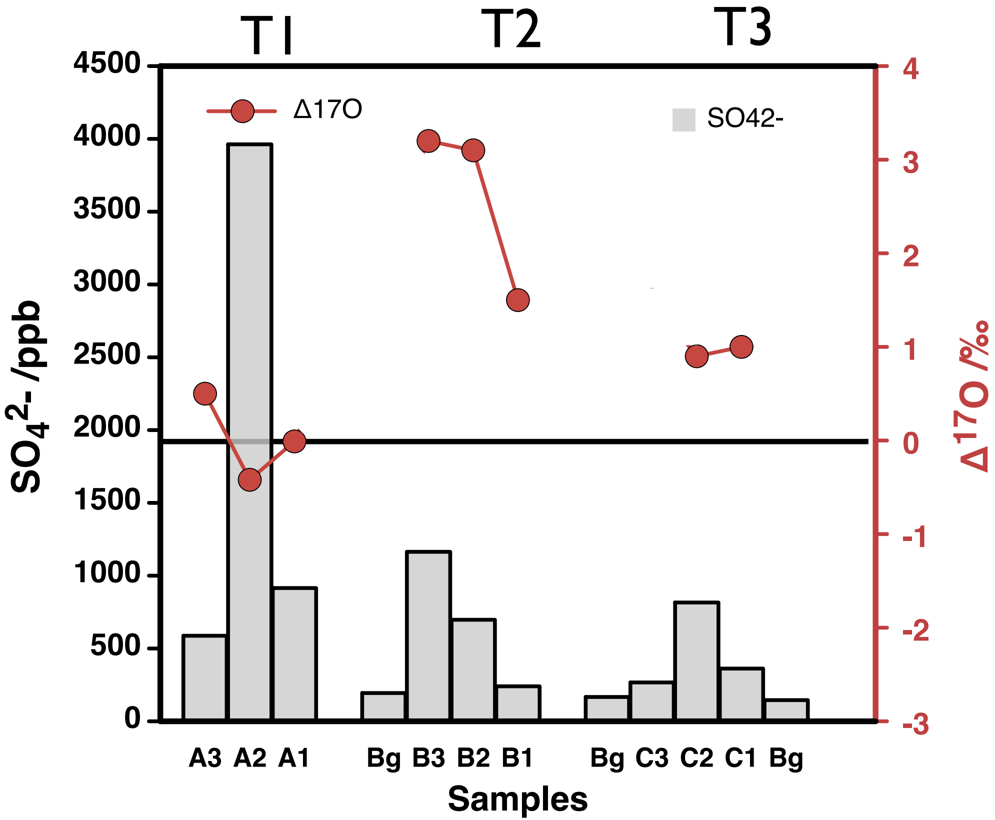


CC BY

Peak T1 shows extremely low $\Delta^{17}O$, never observed before

Peak T2 as expected for standard stratospheric eruptions

Peak T3 shows low $\Delta^{17}O$, in range of previous observation



CC BY

Summary & Conclusions

Peak T1: High SO_4^{2-}, +/- $\Delta^{33}S$, Lowest $\Delta^{17}O$ observed

→ Possible candidate for Toba

Peak T2: Medium SO_4^{2-}, - $\Delta^{33}S$, high $\Delta^{17}O$

→ Missing positive component that precludes any conclusion

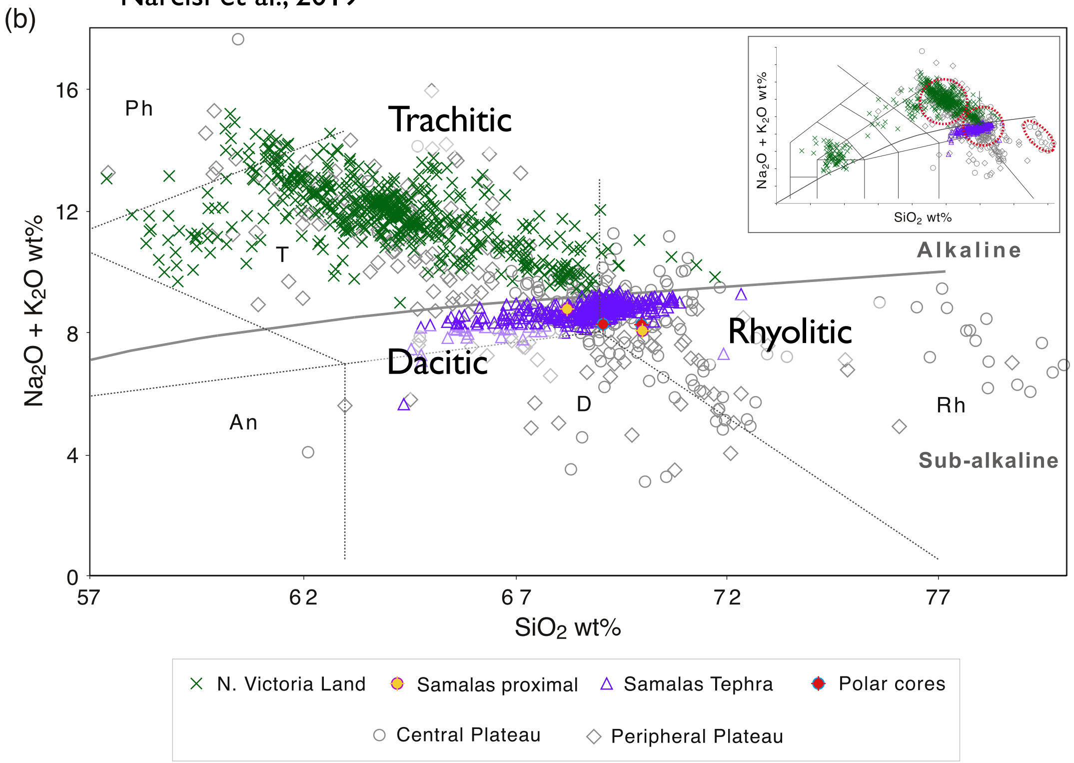
Peak T3: Medium SO_4^{2-}, +/- $\Delta^{33}S$, Low $\Delta^{17}O$

→ Possible candidate for Toba

CC BY

In progress …
Geochemical analysis if shards are present

Narcisi et al., 2019



CC BY

Svensson et al., Clim Past, 2013

« Based on ice core data there are thus several possible candidates for Toba eruption(s), and it cannot ***be excluded that several of them are related to Toba****. ../..*
Several closely spaced large Toba eruptions could, however, help to explain why ***none of the identified ice core events are as strong as would be expected*** *from current geological evidence »,*

CC BY


The End