Persistent draining of the stratospheric $^{10}$Be reservoir after the Samalas volcanic eruption (1257 CE)

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$^{10}$Be, a cosmogenic isotope, recorded in ice cores is a proxy of past solar activity

BUT

Its deposition is influenced by stratospheric volcanic eruptions because:

- $^{10}$Be get attached to aerosols to fall on the Earth’s surface
- The $^{10}$Be reservoir is located in the polar stratosphere

e.g. Poluianov et al. (2016), Webber and Higbie (2007)
The sulphate and $^{10}$Be concentrations were measured in the exact same samples at a sub-annual resolution.

- Significant relationship between the sulphate and $^{10}$Be concentrations for 14 volcanic eruptions detected over the last millennium in 3 different Antarctic ice cores/snow pits, at Vostok, Dome C and South Pole.

- Identification of stratospheric volcanic eruptions (most are unknown) in accordance with other independent methods (Sulphur isotopic anomaly of volcanic sulphate and bipolar volcanism).
Meaning of the relationship: $^{10}\text{Be} = a \ [\text{SO}_4^{2-}] + b$

‘a’ => efficiency of $^{10}\text{Be}$ washout from its stratospheric reservoir

‘b’ => indication on the size of the $^{10}\text{Be}$ stratospheric reservoir at the time of the eruption => ultimately depending on solar modulation
2) Classification of volcanic eruptions

Dendrogram which allowed to identify 4 groups of slopes that would be related to the characteristics of the volcanic eruptions (amount of SO$_2$, altitude)

Group of the lowest slopes: Kuwae and Samalas are the most important of the last millenium

Group of the steepest slopes
Unknown high-latitudes eruptions => vicinity of the $^{10}$Be reservoir

Negative slope
Unknown eruption in 1269CE, 10 years after Samalas (1257CE)

Group of moderated slopes for moderated eruptions which would be Pinatubo or Agung-like (Tens of Tg of SO$_2$, altitude<27km) :
The Samalas eruption (1257 CE)

158 +/- 17 Tg of SO$_2$, 43 km of altitude (Lavigne et al., 2013)

(ex: Pinatubo (1991) 15 Tg of SO$_2$, 25 km (e.g. Guo et al., 2004))

This eruption stand out of the other from many aspects (highest sulphur isotopic anomalie and near-null oxygen isotopic anomaly (e.g. : Savarino et al., 2003, Gautier et al., 2019) => exhaustion of regular oxidative pathways of SO$_2$ (amount effect) and/or altitude effect
Results

3) The Samalas (Indonesia), 1257 CE

- The Samalas has the lowest positive slope of the 14 we studied
- The negative slopes for eruptions following the Samalas eruption (in 1269CE and 1276CE) seems to reflect a disturbance of the $^{10}$Be polar stratospheric reservoir which would have been drained out for at least a decade.

$\rightarrow$ effect of altitude (only gases > 30-35km of altitude and age of air masses of 5yrs) and/or amount of SO$_2$ emitted (delay of SO$_2$ oxidation)
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