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

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Context

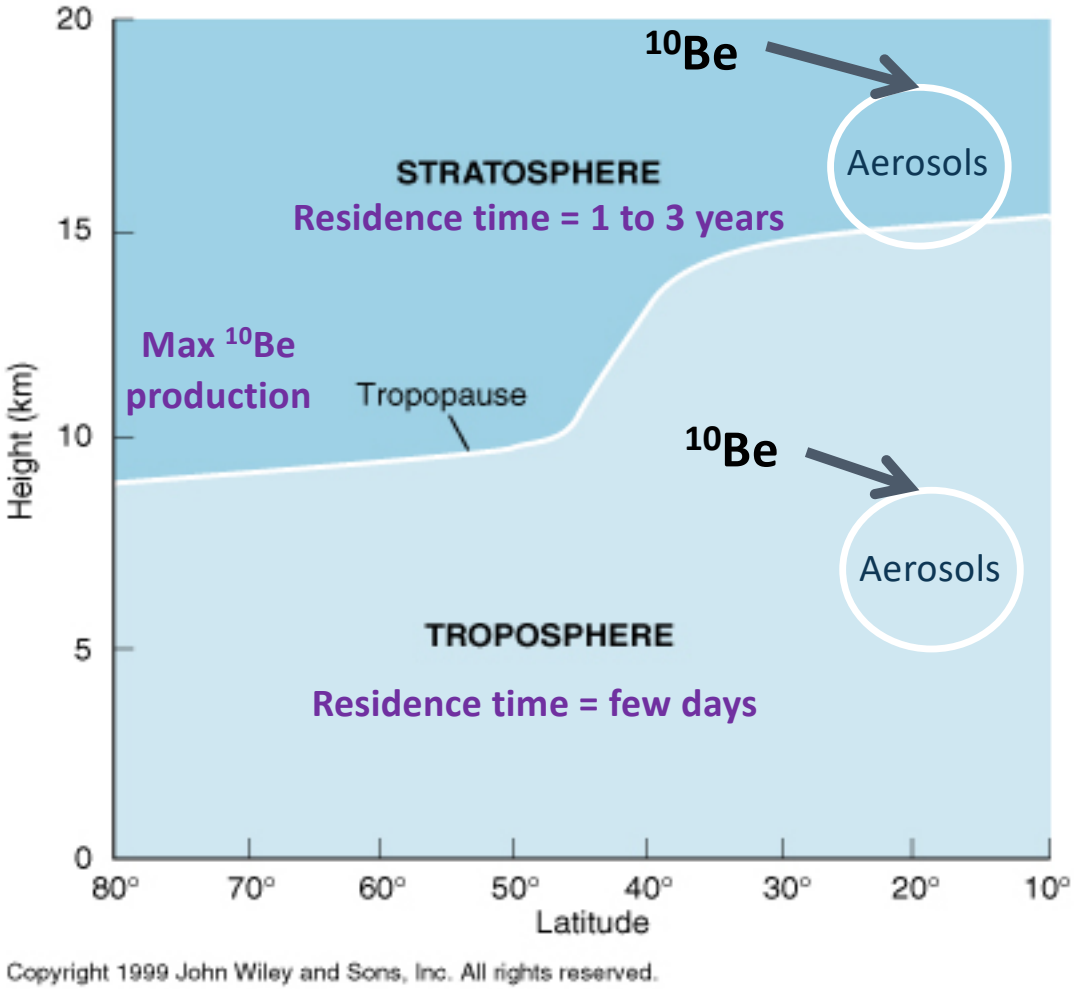
^{10}Be, a cosmogenic isotope, recorded in ice cores is a proxy of past solar activity

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)

Results

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RESEARCH ARTICLE
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Persistent Draining of the Stratospheric ^{10}Be Reservoir After the Samalas Volcanic Eruption (1257 CE)

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Key Points:

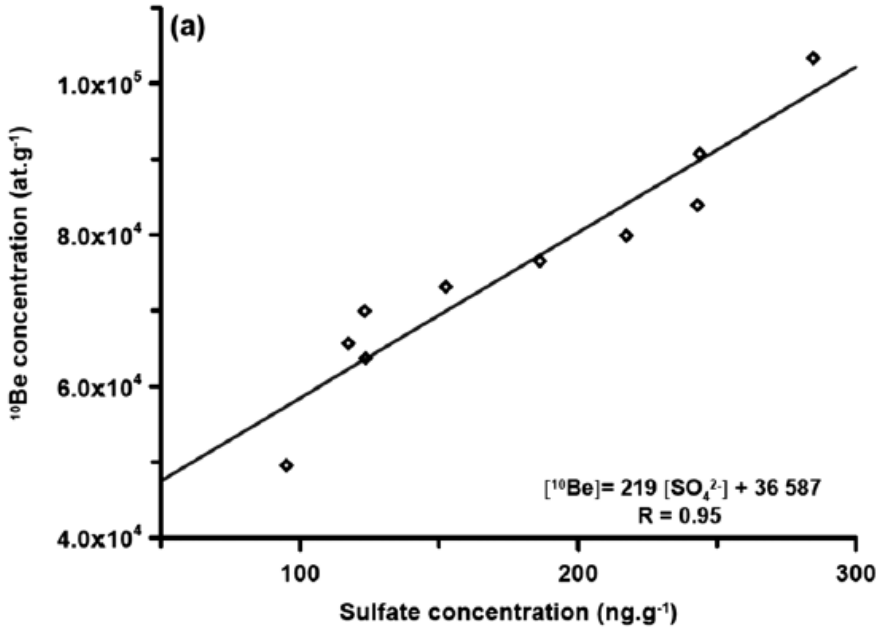
The sulphate and ^{10}Be concentrations were measured in the exact same samples at a sub-annual resolution.

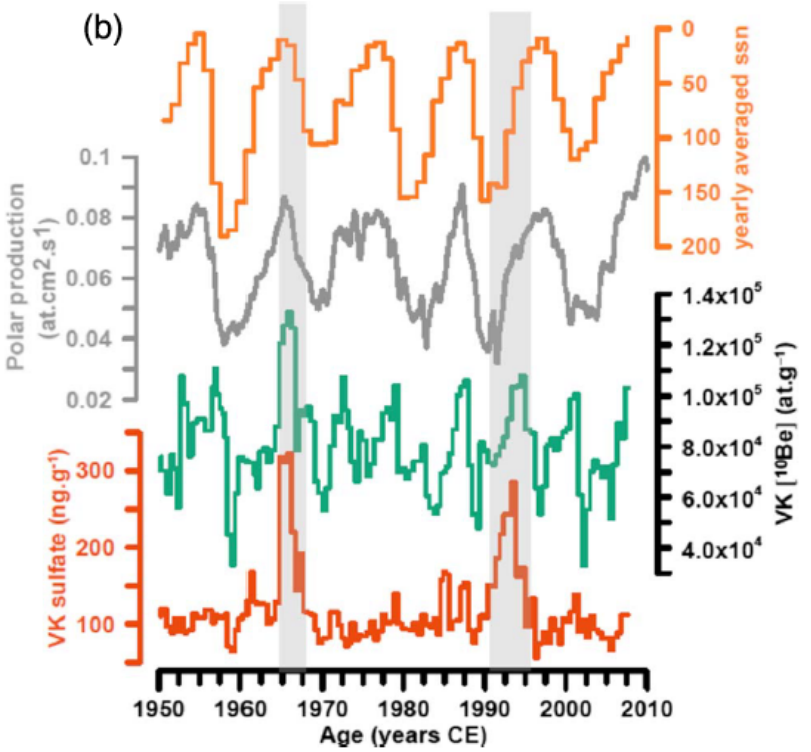
⇒**significant relationship between the sulphate and ^{10}Be concentrations for 14 volcanic eruptions detected over the last millennium in 3 different Antarctic ice cores/snow pits, at Vostok, Dome C and South Pole**

⇒**Identification of stratospheric volcanic eruptions (most are unknown) in accordance with other independent methods (Sulphur isotopic anomaly of volcanic sulphate and bipolar volcanism)**

Results — 1) Link between the ^{10}Be and sulphate concentrations

Exemple : Pinatubo (1991)





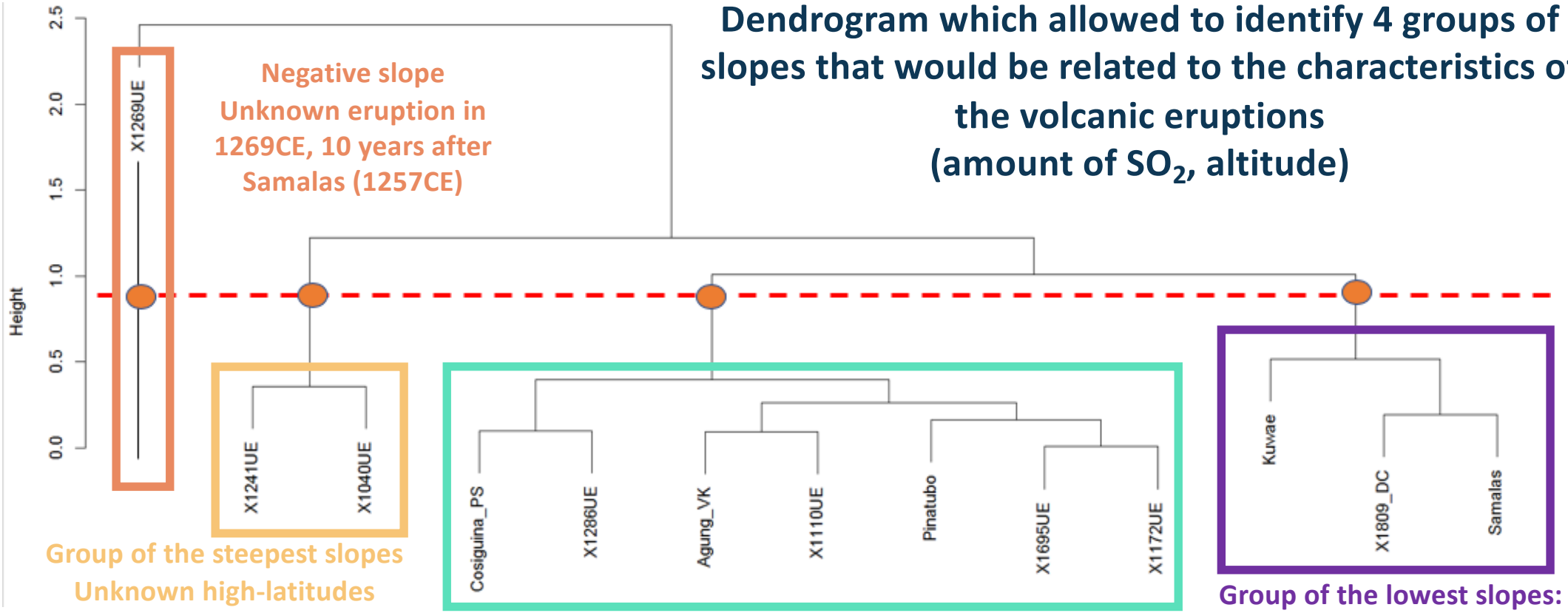
Meaning of the relationship : [^{10}Be] = a [SO_4^{2-}] + b

'a' => efficiency of ^{10}Be washout from its stratospheric reservoir

'b' => indication on the size of the ^{10}Be stratospheric reservoir at the time of the eruption => ultimately depending on solar modulation

Results — 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)



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

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

Group of moderated slopes for moderated eruptions which would be Pinatubo or Agung-like (Tens of Tg of SO_2, altitude<27km) :

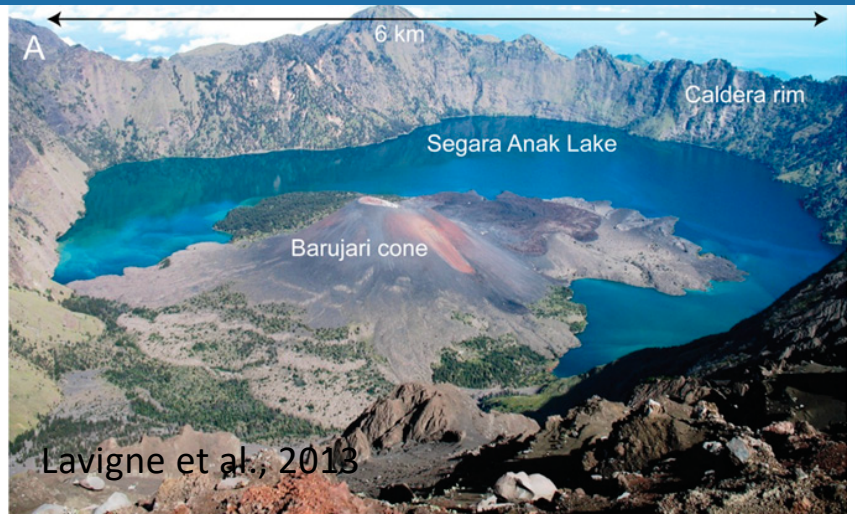
Group of the lowest slopes: Kuwae and Samalas are the most important of the last millenium

Results — 3) The Samalas (Indonesia), 1257 CE

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))

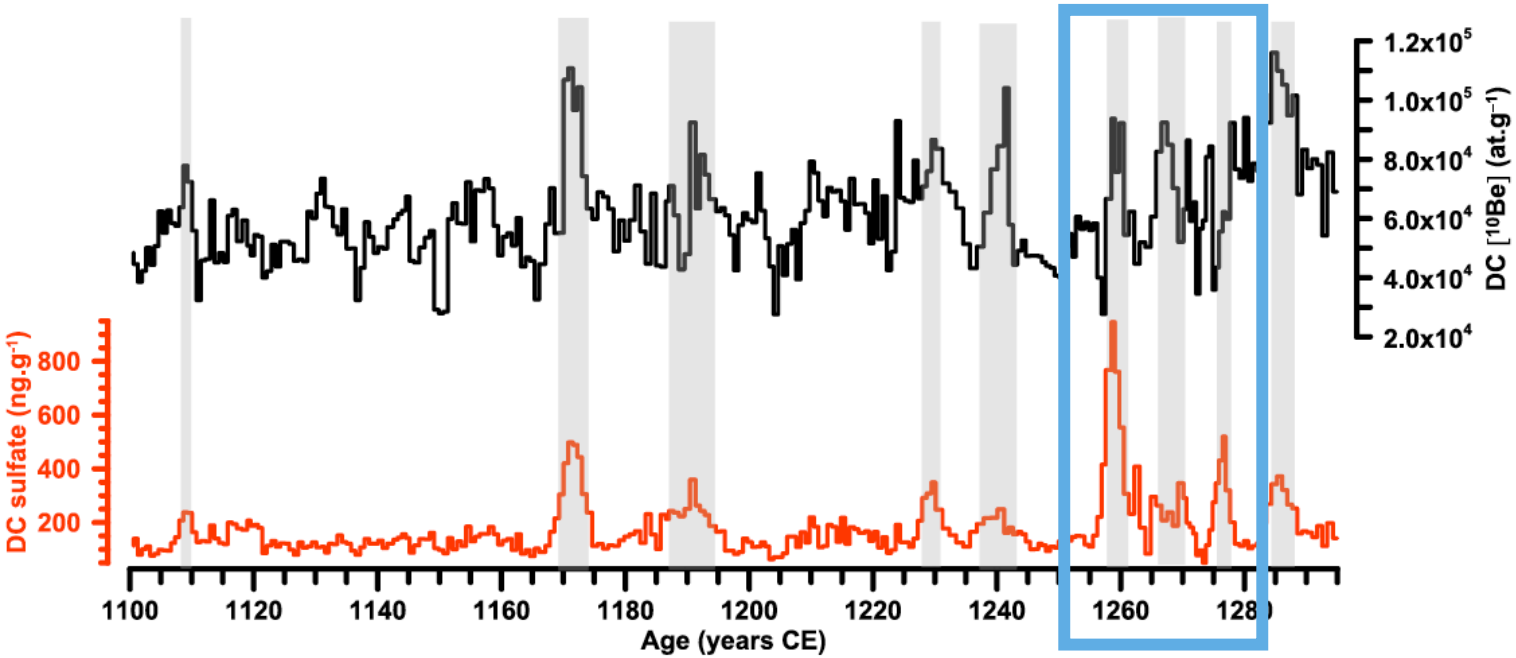


This eruption stand out of the other from many aspects (highest sulphur isotopic anomalie and near-null oxygen isotopic anomaly (e.g. : Savarino et al., 2003, Gautier et al., 2019) => exhaustion of regular oxidative pathways of SO_2 (amount effect) and/or altitude effect

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.

=> 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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