EGU2020-12957
https://doi.org/10.5194/egusphere-egu2020-12957
EGU General Assembly 2020

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

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More than 2,000 analyses of beryllium10 (^{10}Be) and sulphate concentrations were performed at a nominal subannual resolution on an ice core covering the last millennium as well as on shorter records from three sites in Antarctica (Dome C, South Pole, and Vostok) to better understand the increase in ^{10}Be deposition during stratospheric volcanic eruptions.

A significant increase in ^{10}Be concentration is observed in 14 of the 26 volcanic events studied. The slope and intercept of the linear regression between ^{10}Be and sulphate concentrations provide different and complementary information. Slope is an indicator of the efficiency of the draining of ^{10}Be atoms by volcanic aerosols depending on the amount of sulphur dioxide (SO_2) released and on the altitude it reaches in the stratosphere. The intercept provides an appreciation of the ^{10}Be production in the stratospheric reservoir, ultimately depending on solar modulation (Baroni et al., 2019, JGR).

Among all the identified events, the Samalas event (1257 CE) stands out as the biggest eruption of the last millennium with the lowest positive slope. It released (158 ± 12) Tg of SO_2 up to an altitude of 43 km in the stratosphere (Lavigne et al., 2013, PNAS ; Vidal et al., 2016, Sci. Rep.). We hypothesize that the persistence of volcanic aerosols in the stratosphere after the Samalas eruption has drained the stratospheric ^{10}Be reservoir for a decade.

The persistence of Samalas sulphate aerosols might be due to the increase of SO_2 lifetime because of: (i) the exhaustion of the OH reservoir required for sulphate formation (e.g. (Bekki, 1995, GRL; Bekki et al., 1996, GRL; Savarino et al., 2003, JGR); and/or, (ii) the evaporation followed by photolysis of gaseous sulphuric acid back to SO_2 at altitudes higher than 30 km (Delaygue et al., 2015, Tellus; Rinsland et al., 1995, GRL). In addition, the lifetime of air masses increases to 5 years above 30 km altitude compared with 1 year for aerosols and air masses in the lower stratosphere (Delaygue et al., 2015, Tellus). When this high-altitude SO_2 finally returns below the 30 km limit, it could be oxidized back to sulphate and forms new sulphate aerosols. These processes could imply that the ^{10}Be reservoir is washed out over a long time period following the end of the eruption of Samalas.

This would run counter to modelling studies that predict the formation of large particle sizes and

their rapid fall out due to the large amount of SO_2, which would limit the climatic impact of Samalas-type eruptions (Pinto et al., 1989, JGR; Timmreck et al., 2010, 2009, GRL).