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Timing and climate impact of Iceland's largest basaltic eruptions: new insights from ice core archives

Content

Volcanic eruptions are one the most important natural radiative forcings of Earth's climate system. Much of our understanding of volcano-climate impacts comes from the study of tropical eruptions (e.g., Pinatubo and Tambora), and consequently our know of high-latitude eruption impacts is much more limited. This is particularly true for large Icelandic fissure eruptions which can emit huge quantities of sulfur (equivalent to annual global anthropogenic SO2 emissions) and pose severe hazards in terms of air quality and environmental pollution.

Ice cores provide exceptionally high-time-resolution records of volcanic eruptions and their plume fallout. A key development is the analysis of sulfur isotopes in ice core sulfate which encode detailed information about eruption source, plume height and plume evolution, and can be used to determine climate impact. Cryptotephra deposited alongside the sulfur peaks can also be extracted, analysed in conjunction and used to pinpoint the volcanic source of these emissions and their precise timing.

Here, we compare and contrast sulfur isotope and cryptotephra records of the 1783 Laki and 939 Eldgjá basaltic fissure eruptions, which represent the two largest Icelandic S emissions in the last 2000 years. Both eruptions reveal a clear magmatic isotope signal in δ34S with a time evolving pattern that is linked to eruptive degassing and/or atmospheric chemical processing of the plume. Multiple sulfur isotopes (Δ33S), which are traditionally used to distinguish stratospheric vs. tropospheric plumes, show that for both the main Laki and Eldgjá peaks Δ33S is mainly 0 ± 0.2 ‰ and consistent with tropospheric SO2 injection. However, in the case of Eldgjá, Δ33S down to −0.4 ‰ follows the main S peak and is taken as evidence for a stratospheric component and hence a climate impacting phase. Importantly, by analysing cryptotephra associated with these anomalous Δ33S values we found that the ash does do not show geochemical affinity with typical Eldgjá basalt compositions and instead show rhyolitic arc-like signatures. This suggest that an unidentified arc volcano, rather than Eldgjá may be the culprit for the stratospheric S component.

Overall, these new data provide important constraints on the relative partitioning of tropospheric and stratospheric aerosol during large basaltic fissure events, and in the case of Eldgjá, provide new evidence for closely timed Icelandic and arc eruptions. The combination of high-time-resolution S isotopes and cryptotephra offer exceptional insights into the precise timing and potential climate impacts of these major volcanic episodes.

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