Exercise 2 Answers

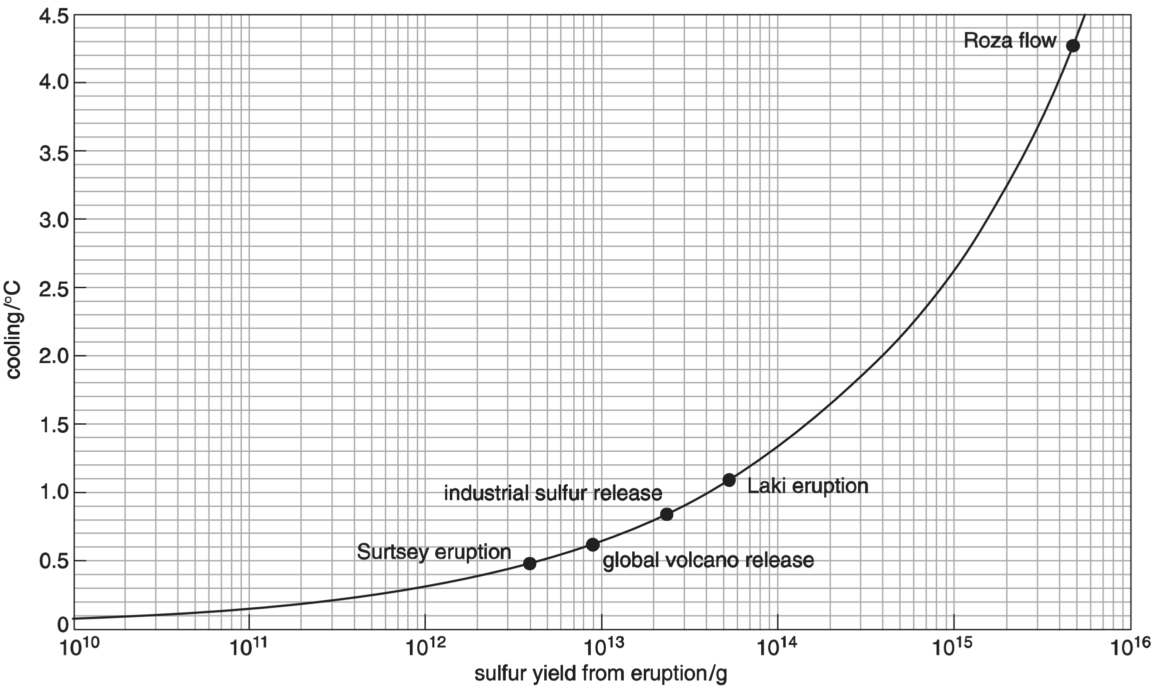
Question 2.1

(a) Your calculation of the influence of the Surtsey eruption should look like this:

If 1cm^3 of lava weighs 3 g, 1 km^3 of lava would weigh 3×10^{15}g. If each gram of lava contains 0.0013 g of sulfur, 3×10^5g contains 3.9×10^{12}g sulfur. You can either determine the expected relative global cooling due to Surtsey from the graph below or calculate it using the equation:

$\Delta T = 5.9 \text{ x } 10^{-5}\ ^{\circ}\text{C}\ (3.9 \text{ x } 10^{12})^{0.31} = 0.46\ ^{\circ}\text{C}$

(b) The reason for the lack of global effects from Surtsey is that the eruptions lasted around 3.5 years and thus the sulfur release was spread over that period. If you plot the present-day global SO_2 release from the world's volcanoes and the output from industry, you will see that both are apparently greater than Surtsey and industrial output appears to be reducing global temperatures by about 0.75 °C. However, it is the timescale over which the release happened that makes the difference. Both the volcano release and industrial output are averaged over a year, but Surtsey lasted 3.5 years. The residence time of sulfur in the atmosphere is only about 0.5 years, so the system was never loaded with the full sulfur release from Surtsey and thus the overall effects were negligible.



Question 2.2

(a) The sizes of Laki and the Roza flows were much larger than Surtsey and, plotted on the graph, they indicate global cooling effects of over 1 °C for Laki and over 4 °C for the Roza flow. The Laki eruption lasted about eight months and much of the major release was on an even shorter timescale. Moreover, anecdotal evidence indicates that the effects were certainly felt all over the Northern Hemisphere. The Roza flow was two orders of magnitude larger but the eruption may have lasted of the order of a decade. However, if we consider the amount which might have been released in each 0.5 years (dividing the total by 20), the global cooling effect would still have exceeded 1.5 °C.

(b) Although a phreatomagmatic eruption would provide the explosive power to propel large amounts of aerosol into the stratosphere, the presence of large quantities of water in the plume would also be expected to dissolve SO_2 and remove it quickly from the atmosphere as the water rained back down. Conversely, the inclusion of large quantities of water in the plume might propel sufficient water into the stratosphere to reduce the saturation effect which limits the production of H_2SO_4 aerosols and enhance the cooling effects of such an eruption. Both these processes are speculative since we have not seen a very large phreatomagmatic eruption on an ocean ridge in historical times.