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New estimates of chemical diffusion rates in the EPICA Dome C ice core

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In order to extract climatically relevant chemical signals from the deepest, oldest Antarctic ice, we must first understand the degree to which chemical ions diffuse within solid ice. Volcanic sulfate peaks are the ideal target for such an investigation because they are high amplitude, short duration (˜3 years) events with a quasi-uniform structure. Here we present analysis of the EPICA Dome C sulfate record over the last 600 kyr, extending previous work which focused only on the Holocene.

We first identify volcanic peaks and isolate them from the non-sea salt sulfate background to reveal the effects of diffusion: amplitude damping and broadening of peaks in the time domain with increasing depth/age. Sulfate peak shape is also altered by the thinning of ice layers with depth. Both processes must be simulated in order to derive effective diffusion rates. This is achieved by running a forward model to diffuse idealised sulfate peaks at different rates while also accounting for ice thinning.

Our simulations suggest effective diffusion rates of sulfate ions on the order of 10-8 m2 yr-1 in the Holocene ice, in agreement with previous work. The effective diffusion rates of the Holocene are higher than for any other time interval. Furthermore, there doesn't appear to be a significant difference in time-averaged diffusion rates between glacial and interglacial periods despite variations in ice chemistry. Implications for the preservation of volcanic sulfate peaks, and also climatic signals, in the upcoming Beyond EPICA ice core will be discussed.

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Track Classification: The Oldest Ice challenge, and the preservation of climatic signals in the deepest ice