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Effective diffusivity of sulfuric acid in Antarctic ice cores

Content

Volcanic deposition of sulfuric acid, identified by sulfate, sulfur, or electrical conductivity measurements, in Antarctic ice cores is important both for understanding past volcanic activity and for synchronizing ice core timescales. Sulfuric acid has a low eutectic point and can potentially exist in liquid at grain boundaries and veins, accelerating diffusion. A high effective diffusivity will obscure the climate history and ability to confidently match similar peaks among ice cores in the older portions of ice cores. Here we use records of sulfate and electrical conductivity from 5 Antarctic ice cores to estimate the effective diffusivity of sulfuric acid. We calculate the mean concentration gradient and the width of prominent volcanic events, and analyze their evolution with depth/age. Because the sulfuric acid concentrations depend on the climate at deposition, we focus on the EPICA Dome C where multiple glacial-interglacial cycles allow comparisons among similar climate states. We find that the effective diffusivities for interglacials and glacial maximums are similar, ~5 × 10-9 m2 a-1, which is an order of magnitude lower than a previous estimate derived from the Holocene portion of EDC (Barnes et al., 2003). The effective diffusivity is not obviously affected by the ice temperature until about -10℃, which is 2800m depth where anomalous sulfate peaks begin to be observed (Traversi et al., 2009). The low effective diffusivity suggests that sulfuric acid is not readily diffusing in liquid-like veins in the upper portions of the Antarctic ice sheet and raises a question of whether the sulfuric acid records might be preserved in deep, old ice if the ice temperature remains well below the pressure melting point.

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