Can sulfate signatures in ice cores verify the source volcano?

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Detailed volcanic records developed from continuous glaciochemical series in a number of West Antarctic ice cores reveal and improve the overall chronological record of Antarctic, South American, and equatorial volcanism. Ages of several large equatorial or southern hemisphere volcanic eruptions coincide with detected sulfate peaks in the developed volcanic ice chemistry records. However, geochemical 'fingerprinting' using electron microprobe analysis of glass shards filtered from meltwater samples adjacent to several sulfate peaks points to Antarctic volcanic centers as sources. These centers include Balenny Is., The Pleiades, Mt. Berlin, Mt. Takahe, Mt. Melbourne, as well as Mt. Hudson and possibly Mt. Burney volcanoes of South America.

Deposition of volcanic sulfate in West Antarctic snow from global- scale eruptions is thought to mainly occur by transport through the mid-upper troposphere and stratosphere (Legrand and Delmas, 1987; Dibb and Whitlow, 1996; Legrand and Wagenbach, 1999), but appears to be dependent on several additional factors. The stratospheric contribution of sulfate to Antarctic snow is generally assumed to be minimal (Legrand, 1997; Bergin and others, 1998) except after global scale volcanic eruptions (Legrand and Delmas, 1987; Dai et al., 1991; Dibb and Whitlow, 1996).

Volcanic sulfate from small local eruptions may be delivered through the troposphere or lower stratosphere, and appears to have the most significant impact on the area near the source eruption. Circulation patterns of lower tropospheric air masses influence magnitude of background sulfate concentration as controlled by elevation and distance from the coast, but the contribution from local volcanic eruptions is much greater than that of background sulfate. Glass shards associated with local, Antarctic volcanic eruptions overall show associations with the large sulfate signals. We observed a complex, non-linear relationship between the magnitude of the eruption and the sulfate signal. Three sulfate signals at 1259, 1809 and 304 C.E. possibly associated with tephra from Antarctic volcanoes show that local volcanic eruptions produce one of the largest sulfate spikes in the record. This findings suggest the need for reevaluation of proposed earlier tropical eruption sources for 1259 and 1809 volcanic signals.

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