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Ash on ice: Signals of New Zealand supereruptions in deep Antarctic climate records

SIMON J BARKER[1], ALEX MATTIN[1], ANNA MILLER[1], HOLLY WINTON[1], STEPHEN PIVA[1], ANDREA BURKE[2], WILLIAM HUTCHISON[3], MICHAEL SIGL[4], RACHAEL RHODES[5], COLIN J N WILSON[1] AND NELS IVERSON[6]

[1]Victoria University of Wellington
[2]University of St Andrews
[3]School of Earth and Environmental Sciences, University of St Andrews
[4]Oeschger Centre for Climate Change Research, University of Bern
[5]University of Cambridge, United Kingdom
[6]New Mexico Institute of Mining and Technology

Ice cores preserve vital information about Earth's past that can be used to assess changes in climate at high temporal resolution. These archives are also increasingly being used to assess the frequency and impacts of past volcanic eruptions. Volcanic sulfate is deposited over the poles months to years after large global eruptions and can be used as a time marker for linking ice records. In addition to sulfate anomalies, insoluble particle analysis can hold clues about the unique source of the eruption, where glass shards can be extracted from ice and analyzed to pinpoint magma composition and volcanic origin. With New Zealand being in a prime location for atmospheric ash transport to the south, Antarctic ice cores can be used to provide new information on past explosive eruptions. Here we present case studies of three events, the 1.8 ka Taupō eruption, the 25.5 ka Ōruanui supereruption and the 349 ka Whakamaru supereruption. Glass shards from these events have now been uniquely located and fingerprinted in multiple ice cores using a range of techniques, meaning that high resolution ice records can be used to assess the timing and impacts of these events. The Ōruanui supereruption is recorded as one of the largest sulfate anomalies in ice core records, with considerations of magma chemistry highlighting that the event likely ejected >390 Tg of sulfate into the stratosphere during the Last Glacial Maximum. However, we show that the sulfate anomaly, sulfur isotopic signature and presence of glass shards from this event varies significantly between cores, reflecting variable circulation and preservation, highlighting the challenges with interpreting volcanic signals in ice records. In contrast, the 235 AD Taupō event produced only a minor anomaly, despite its size and energetic plume. The Whakamaru supereruption represents one of the largest volcanic eruptions of the Quaternary at 349 ka and is now the oldest non-Antarctic volcanic event documented in ice. The strength of the sulfate anomaly from such large events and reduced sulfate diffusion rates in deep ice highlight the potential of well-characterized New Zealand supereruptions as novel and independent dating tools for the deepest ice cores.