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Assessing impacts of explosive volcanism on climate and society at the end of the Roman Republic and Ptolemaic Kingdom

Content

Explosive volcanism is the primary driver of short-term climate variability. Large eruptions inject sulfur dioxide into the stratosphere where it is oxidized to bright sulfate aerosols that reflect incoming solar radiation, resulting in sometimes extreme cooling of Earth's surface and changes in precipitation for months to years following the eruption. Well-dated records of volcanic fallout from glacier ice, combined with accurately dated climate proxies from tree rings, speleothems, and other natural archives, provide a means to evaluate the magnitude and drivers of past climate variability and, together with archaeological or historical material, assess potential impacts on past societies.

Here we present and discuss detailed measurements of sulfur, volcanic tephra, and other fallout in a recently expanded array of Arctic ice cores to evaluate explosive volcanism and its impact on climate during the 1st C BCE. We highlight an eruption in early 43 BCE recently identified using tephra geochemistry in Greenland ice to be the Okmok II eruption in Alaska (McConnell et al., PNAS, 2020), and use Earth System and other model simulations, as well as European and Asian tree-ring and speleothem climate proxies, to evaluate the likely climate effects from this massive eruption.

The first-century BCE demise of the Roman Republic and Ptolemaic Kingdom, and subsequent rise of the Roman Empire were among the most important political transitions in the history of Western civilization. Model simulations indicate that in 43 and 42 BCE following the Okmok II eruption, seasonal temperatures in specific Mediterranean regions were as much as 7°C below normal and unusually wet. While it is difficult to establish direct causal linkages to thinly documented historical events, the wet and very cold conditions from this massive eruption on the opposite side of Earth likely resulted in crop failures, famine, and disease that exacerbated social unrest and contributed to political realignments throughout the Mediterranean at this critical juncture of Western civilization.

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