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The role of volcanism in global-scale climate cooling at the Eocene-Oligocene transition.

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A multimillion-year cooling trend started around 50 Ma, when the warm Paleogene greenhouse climate began to cool into the early Oligocene (~34 Ma) and culminated with an abrupt global cooling episode and the formation of partial/ephemeral Antarctic ice sheets at the Eocene-Oligocene boundary – a climate event known as the Eocene-Oligocene transition (EOT). Most studies attribute the EOT to either i) tectonically-driven ocean circulation changes or ii) a gradual decline in CO_2. Volcanism was previously disregarded as an EOT cooling mechanism, but recent research on large igneous provinces (LIPs) demonstrates their potential climate forcing ability. Large igneous provinces may generate cooling through rapid weathering of juvenile volcanic products and/or inciting changes in marine productivity – both of which intensify CO_2 drawdown. Additionally, injection of sulfur dioxide into the atmosphere and the formation of sulfate aerosol impacts the Earth's radiative budget and indirectly affects atmospheric circulation, which temporarily reduces surface temperatures.

Two LIPs were active around the EOT: i) the Afro-Arabian LIP (main phase: 31–29 Ma; pre-cursor event: ~34 Ma) and ii) the Sierra Madre Occidental siliceous LIP, particularly the ignimbrite “flare-up” activity (~34–28 Ma). Although comprising varying types of volcanism, both LIPs are potential candidates to cause climate cooling. This possible association warrants further investigation into the link between LIP volcanism and the EOT. Mercury (Hg) is a trace component of volcanic gas emitted from modern volcanoes which can be globally distributed, deposited into the oceans and transferred into sediments. Here we use sedimentary Hg/TOC ratios as a geochemical tracer of volcanism. We investigate Hg/TOC ratios in records from the Para-Tethys Sea and eastern Equatorial Atlantic Ocean, which we consider alongside volcanic, sedimentary and environmental influences on Hg to resolve whether Hg anomalies are related to internal sedimentary processes or external Hg loading. We do not find significant, consistent Hg/TOC peaks across the EOT. A period of consecutive Hg/TOC and Hg peaks occur after ~32 Ma, which could possibly be attributed to LIP volcanism, but a more detailed characterisation of depositional conditions is required. At this stage, we do not find substantial evidence for volcanism-induced climate forcing at the EOT.