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# PETM Onset Triggered by Intense Volcanism in the North Atlantic Revealed by Tellurium

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Large Igneous Provinces (LIPs) are thought to have played a significant role in all the major extinction events throughout Earth's history. Immense atmospheric injection of volcanic $CO_2$ and $SO_2$ and volatiles released during thermal metamorphism of crustal rocks were likely responsible for global hyperthermia, anoxia, and extinction. However, establishing time frames to link relatively short-lived LIP volcanism (< $10^6$ years) with rapid environmental change ($10^4$ – $10^5$ years) remains a serious challenge.

The North Atlantic Igneous Province (NAIP), with a volume of about 6.6 x $10^6$ $km^3$ was emplaced in the late Paleocene and early Eocene during continental rifting in the North Atlantic. The NAIP overlaps in age with the Paleocene – Eocene Thermal Maximum (PETM) at 56 Ma, marked by rapid warming and an abrupt negative carbon isotope excursion (CIE) which lasted about 170 ka. Although the NAIP is thought to have been responsible for the PETM, the main trigger remains unclear.

Previous work on correlating distal sedimentary successions to NAIP volcanism mostly relied on mercury (Hg) enrichments. However, Hg and Hg/TOC chemostratigraphies through the PETM are often contradictory and appear to be strongly affected by non-volcanic secondary effects. In contrast, we find that using sedimentary tellurium (Te) concentrations normalized to immobile trace elements such as thorium (Th) may represent a better proxy for volcanic input. Sediments from both our study sites - Fur, (Denmark), and DSDP550 (Goban Spur, North Atlantic) exhibit high but variable Te concentrations before the onset of the CIE and high concentrations (up to 800 ppb) throughout the main hyperthermic period. Te concentrations and Te/Th ratios decrease during the PETM recovery phase, and during the deposition of the positive Danish Ash Series until about 1 Ma after the PETM onset. Ultimately, we find that NAIP magmatism initiated before the PETM consistent with radiometric ages, and that the main phase of NAIP magmatism spans the PETM. The onset of rapid warming and the abrupt CIE at the P – E boundary was most likely triggered by feedback effects related to ongoing magmatism, or by volatile release from sediments intruded by NAIP magmas.