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# Unearthing the PETM in the Indian tropics: *n*-alkane and bulk carbon isotope records from the Barmer Basin

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ABSTRACT

The Paleocene–Eocene Thermal Maximum (PETM) represents one of the most pronounced global hyperthermal events of the Cenozoic, characterized by rapid warming, carbon cycle perturbations, and substantial environmental reorganization. Despite its global significance, tropical terrestrial records remain underrepresented, particularly from the Indian subcontinent. This study presents a high-resolution geochemical and isotopic investigation of Paleogene sediments from the Sonari Lignite Mine (SLM), Barmer Basin of western India, to reconstruct paleoenvironmental responses to the PETM. Bulk organic carbon ($\delta^{13}C_{bulk}$) and compound-specific n-alkane isotope ($\delta^{13}C_{n\text{-alkane}}$) data reveal a distinct negative Carbon Isotope Excursion (−ve CIE), with $\delta^{13}C_{31}$ reaching a minimum of −40.5 ‰ and a total excursion magnitude of ~8.6 ‰, among the highest rec orded in terrestrial PETM sequences. Biomarker distributions indicate a mixed organic matter source, dominated by higher plant input, with secondary contributions from aquatic macrophytes and microbial sources. The onset of the CIE at ~45.95 m is supported by dinocyst-based biostratigraphy, including the acme of *Apectodinium augustum*. A smaller pre-onset excursion suggests pulsed carbon release prior to the main event. Regional environmental changes include increased humidity, intensified hydrological cycling, and transient sea-level rise, interpreted from declining Carbon Preference Index (CPI) values, reduced terrigenous/aquatic ratio (TAR), and a surge in short-chain n-alkanes. The magnitude of the CIE and associated climatic shifts at SLM reflect a robust expression of PETM-related feedbacks in a low-latitude, monsoon-influenced setting. These results underscore the significance of tropical terrestrial archives in resolving the spatial heterogeneity of PETM climate responses and highlight the importance of the Indian subcontinent as a key region for documenting low-latitude tropical climate and vegetation dynamics during hyperthermal events.

## 1. Introduction

Earth's climate and biosphere have been significantly changed by episodes of relatively short, intense global warming and massive carbon input into the ocean-atmosphere system, known as hyperthermal events (Zachos et al., 2008). The Paleocene-Eocene Thermal Maximum (PETM), which occurred around 56 million years ago (Ma), is among the most prominent and best-studied. It was characterized by a sharp global warming of ~5–9 °C (Kennett and Stott, 1991; Zachos et al., 2006; Sluijs et al., 2006) and a major negative Carbon Isotope Excursion (−ve CIE) of 2.5–8 ‰ (McInerney and Wing, 2011), indicating the rapid release of isotopically light carbon into the atmosphere (Dickens et al., 1997; Zeebe et al., 2009; Cui et al., 2011). The event lasted approximately 100,000 years and was associated with widespread deep-sea carbonate dissolution due to ocean acidification (Zachos et al., 2005; Gibbs et al., 2010; Babila et al., 2016, 2018).

The PETM triggered significant global ecological upheaval. Terrestrial and marine organisms exhibited range shifts, evolutionary

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