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Editorial: Curbing carbon emissions: insight from the ecosystem evolution during ancient hyperthermal events

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Editorial on the Research Topic
Curbing carbon emissions: insight from the ecosystem evolution during ancient hyperthermal events

As guest editors for the 2023 Edition of Frontiers in Earth Science featuring the article Research Topic titled "*Curbing Carbon Emissions: Insight from the Ecosystem Evolution During Ancient Hyperthermal Events*," we express our immense satisfaction with the caliber of contributions from international experts. We extend our gratitude for their valuable insights into this research theme. The Research Topic encompasses comprehensive reports on deep-time extreme hyperthermal events, notably the Early Triassic Extreme Heat Event and the Paleocene-Eocene Thermal Maximum. These contributions significantly enhance our comprehension of the repercussions of hyperthermal events on marine productivity, the marine ecosystem, and lacustrine environments. Beyond the scientific discourse on hyperthermal events, the Research Topic includes research articles focusing on technology designed to mitigate carbon emissions while ensuring sustainable energy supply.

Woods et al. delve into the well-documented hyperthermal event at the Permian-Triassic boundary, revealing a rapid 5°C increase in surface seawater temperature within 0.5 million years (Sun et al., 2012). Their study of the Ursula Creek deepwater section in western British Columbia analyzes productivity and redox conditions. Findings indicate that the Early Triassic witnessed anoxic conditions and subdued productivity due to ocean stagnation or weak circulations during the greenhouse period. This regime was overturned by reestablishing coastal upwelling until a cooling event at the end of the Early Triassic. The persistent anoxia significantly impacted the marine ecosystem, delaying recovery from the end-Permian mass extinction (Lau et al., 2016). Traditional concepts are challenged by recent findings of Dai et al. (2023), which suggest a faster recovery in overarching anoxic conditions.

Li et al. contributed to the reconstruction of the Eocene to Miocene palaeoclimate of the Qaidam Basin by the Research Topic of carbon and oxygen isotopes. Utilizing

geochemical data extracted from lacustrine carbonate, they identified three aridity events at 40–32 Ma, 22–20 Ma, and 13 Ma. These events, closely tied to variations in carbon and oxygen isotope composition, are attributed to the regression of the Paratethys Sea, Tibetan Plateau uplift, global cooling, and tectonic events. This case study sheds light on climate changes in a lacustrine lake following the Paleocene-Eocene Thermal Maximum, coupled with a subsequent continuous cooling event.

Addressing the contemporary challenge of balancing carbon emissions and energy security, understanding the geochemical characteristics of this deep natural gas would contribute valuable knowledge for the energy sector, offering a potential solution in the pursuit of cleaner energy during the ongoing energy transition. Studies on natural gas preserved in diverse geological formations, such as marine gypsum-salt strata, terrestrial shales, and marine-terrestrial transitional shales, are presented in this Research Topic. Shi et al. explore deep natural gas trapped in Ordovician gypsum-salt strata in China's Ordos Basin. The study identifies the gas hydrocarbon-dominated source with minor non-hydrocarbon contributions. Crucially, sub-salt natural gas is concentrated in moderately mature cracks, holding promising reserves. The research provides insights into the Ordovician subsalt natural gas genesis and its potential as a significant energy resource. Wang et al. focus on the Upper Triassic Xujiahe Formation in the Sichuan Basin, China, examining its terrestrial shales. The study reveals significant thickness, high maturity, and substantial gas generation potential. This exploration of source rocks sheds light on the promising shale gas reserves in the Sichuan Basin. The findings underscore the importance of understanding the geochemical characteristics of source rocks in diverse geological formations, contributing to the broader discussion on reliable energy sources amid the ongoing global transition. Chen et al. investigate the geochemical and gas-bearing characteristics of the Late Permian Longtan Formation in southern Sichuan, China. The study reveals the dominance of vitrinite in organic matter, exhibiting high maturity and gas generation potential. The findings underscore the promising reserves of shale gas in the marine-continental transitional shales of the Longtan Formation. Understanding the geochemical properties of these shales contributes to the assessment of reliable energy sources during the ongoing energy transition. The research emphasizes the significance of shale gas exploration in diverse geological formations for sustainable energy solutions.

Highlighting the pivotal role of technology in shale gas exploration and development, Jiao et al. introduce a quantitative method for characterizing microcrack networks, crucial reservoirs for shale gas. Their findings emphasize the substantial impact of microcrack degree on reservoir quality, highlighting the correlation between a high degree of microcracks and initial productions.

In the broader context of the current global challenges, notably the sixth mass extinction linked to greenhouse warming and anthropogenic activities (Dirzo et al., 2014; Strona and Bradshaw, 2022), this Research Topic aims to stimulate interest in global warming and energy transition. By doing so, we aspire to deepen our understanding of the driving forces behind the sixth mass extinction and foster informed responses to mitigate its impact. We anticipate that this Research Topic will catalyze further exploration and dialogue in these critical areas.

Author contributions

WL: Writing–original draft, Writing–review and editing. ML: Writing–original draft, Writing–review and editing. WS: Writing–original draft, Writing–review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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