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Adaptation to deep-sea methane seeps from Cretaceous shallow-water black shale environments?

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Sulfide-enriched environments in shallow water were considered as sites where animals acquire pre-adaptations enabling them to colonize deep-sea hydrothermal vents and seeps or where they survived extinction events in their deep-sea habitats. Here we present upper Cenomanian (early Late Cretaceous) shallow-water seep communities from the Tropic Shale in the Western Interior Seaway, USA, that lived during a time of extremely warm deep-water temperatures, which supposedly facilitates adaptations to the deep sea, and time-equivalent with a period of widespread oceanic and photic zone anoxia (OAE 2) that supposedly extinguished deep-water vent and seep faunas. Contrary to the expectation, the taxa inhabiting the Tropic Shale seeps were not found at any coeval or younger deep-water seep or vent deposit. This suggests that (i) pre-adaptations for living at deep-sea vents and seeps do not evolve at shallow-water methane seeps, and probably also not in sulfide-rich shallow-water environments in general; (ii) a low temperature gradient from shallow to deep water does not facilitate onshore-offshore adaptations to deep-sea vents and seeps; and (iii) shallow-water seeps did not act as refuges for deep-sea vent and seep animals. We hypothesize that the vast majority of adaptations to successfully colonize deep-sea vents and seeps are acquired below the photic zone.