

Fading of a sulfate-methane transition in deep and hot subseafloor sediments from the Nankai Trough

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Biogeochemical processes in subseafloor sediments change significantly over geological timescales due to changing oceanographic, climatic or depositional conditions. Using dynamic reactive transport modeling, we reconstructed the evolution of biogeochemical processes over the past 5.5 million years in ~1.2-km deep and up to 120°C hot sediments from International Ocean Discovery Program Site C0023 in the Nankai Trough, which records a complex depositional and thermal history. A distinctive feature is an inverse sulfate-methane transition (SMT) with a broad overlap zone between sulfate and methane of ~100 m, located in 80° to 85°C hot sediments. This temperature coincides with the known temperature limit of anaerobic methane-oxidizing microbial communities. Based on the reactive transport model, we show that the inverse SMT was established ~2.5 million years ago (Ma) after the onset of biogenic methanogenesis and anaerobic oxidation of methane (AOM) as a consequence of increased organic carbon burial. Depth-integrated AOM rates decreased markedly since the beginning of trench-style deposition and an associated rapid heating of ~50°C across the sediment column ~0.4 Ma. We argue that the activity of anaerobic methane-oxidizing communities at the inverse SMT has already started to cease and that the SMT is in the process of disappearing. This is the first study that documents the successive fading of an SMT and the decrease in the efficiency of this microbial methane sink as a result of sediment temperature increasing beyond the threshold of being suitable for anaerobic methane-oxidizing microbial communities.