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Climate oscillations reflected in the Arabian Sea subseafloor microbiome

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Marine sediment contains a vast microbial biosphere that influences global biogeochemical cycles over geological timescales. However, the environmental factors controlling the stratigraphy of subseafloor microbial communities are poorly understood. We studied a sediment core directly underlying the Arabian Sea oxygen minimum zone (OMZ), which exhibits organic carbon rich sapropelic laminae deposited under low oxygen conditions. Consistent with several other cores from the same location, age dating revealed the sapropelic layers coincide with warm North Atlantic millennial-scale Dansgaard-Oeschger events, indicating a direct link between the strength of the OMZ and paleoclimate. A total of 214 samples spanning 13 m and 52 Kyr of deposition were selected for geochemical analyses and paleoclimate proxy measurements, as well as high-throughput metagenomic DNA sequencing of bacteria and archaea. A novel DNA extraction protocol was developed that allowed for direct (unamplified) metagenomic sequencing of DNA from each sample. This dataset represents the highest resolved sedimentary metagenomic sampling profile to date. Analysis of these data together with multiple paleoceanographic proxies show that millennial-scale paleoenvironmental conditions correlate with the metabolism and diversity of bacteria and archaea over the last glacial-interglacial cycle in the Arabian Sea. The metabolic potential for bacterial denitrification correlates with climate-driven OMZ strength and concomitant nitrogen stable isotope fractionation, whereas catabolic potential reflects changing marine organic matter sources across the Last Glacial Maximum. These results indicate that the subsisting microbial communities had been stratified to a large extent by paleoceanographic conditions at the time of deposition. Paleoenvironmental conditions should thus be considered as a mechanism that can help explain microbiome stratigraphy in marine sediment.