Thermophilic endospores in cold sediments indicate long term survival and dispersal following a former life in warm anoxic environments

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Microorganisms have been repeatedly discovered in environments that do not support their metabolic activity. In a striking example of this, Arctic marine sediments receive a supply of endospores of thermophilic sulfate-reducing bacteria in excess of 10^8 cells m^{-2} y^{-1}. This flux into a permanently cold habitat implies passive dispersal of endospores from a warm anoxic environment, and potentially long-term survival during transport. Endospores are well suited for this compared to other organisms, and the large numbers of these and related thermophilic *Clostridiales* discovered in cold sediments from around the world present a model for undestanding survival and dispersal. Furthermore, the genomics and physiology of thermophilic endospores could shed light on the biogeochemistry and functional diversity of distant and possibly ancient environments. These kinds of research questions can be accessed through endospore germination experiments, which have revealed multiple lineages of anaerobic thermophiles that are rapidly enriched when sediments are incubated at high temperature (50-70°C growth range). Different pheno- and phylotypes of thermophilic endospores also display variable biogeography in the cold ocean, hinting at a diversity of dispersal histories. Endospore-forming *Firmicutes* are commonly detected in the 'deep biosphere', and consistent with this, genomics of the thermophilic endspores in cold sediments point to closest relatives coming from deep petroleum bearing sediments or deep sea mid ocean ridge habitats. Biogeography combined with genomics therefore enables endospore biomarkers to shed new light on far away extreme environments that are often challenging to visit or sample, suggesting a new role for endospores as bioproxies for understanding past and present life in the deep subsurface.