Habitability of Methane Hydrates: Insights from Omics

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Gas hydrates, also known as clathrates, are cages of ice-like water crystals encasing gas molecules such as methane. Because hydrates form under high pressure and low temperature, their distribution on Earth is limited to permafrost and continental margins. Methane hydrates occur elsewhere in the solar system and may be habitable environments, but any life that can persist in brine pockets within methane hydrate must contend with high salinity (up to ~3x that of seawater), low water potential, low-temperature, and high-pressure conditions. We assessed the habitability of gas hydrates using omics approaches; specifically, we identified unique functions of gas hydrate-dwelling microbes that may enable microbes to survive in these extreme conditions on Earth and possibly other planetary bodies. DNA and protein were extracted and sequenced from sediments at 69 mbsf, within the gas hydrate stability zone, at IODP Site 1244, Hydrate Ridge, off Oregon, USA. We examined the metabolic potential of a metagenome-assembled genome (MAG) belonging to the most abundant bacterial phylum, Atribacteria (86% of total 16S rRNA amplicons). Our Atribacteria MAG contained genes for a novel respiratory complex and numerous strategies for tolerance of osmotic stress, including biosynthesis pathways for unusual osmolytes such as di-myo-inositol-phosphate (DIP) made by hyperthermophiles. The MAG also contained other possible environmental stress adaptations including glycosylation, membrane modifications, and a novel regulator for transport of carboxylic acids and branched chain amino acids.

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