Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.24571

Probing the origins of methane from headspace and void gas isotopologues in the Nankai Trough, IODP Expedition 370, Site C0023A

MANLIN XU[1,2], ANGELINA M SERAFINI[1], AKIRA IJIRI[3], JIAYANG SUN[4], ELLEN LALK[5], DAVID T WANG[1], VERENA B. HEUER[6], FUMIO INAGAKI[7], JAMES FARQUHAR[4] AND SHUHEI ONO[1]

[1]Massachusetts Institute of Technology
[2]Woods Hole Oceanographic Institution
[3]Kobe University
[4]University of Maryland
[5]Woods Hole Coastal and Marine Science Center
[6]MARUM – Center for Marine Environmental Sciences, Faculty of the University of Bremen
[7]JAMSTEC – Japan Agency for Marine-Earth Sciences and Technology

Presenting Author: manlinxu@mit.edu

Methane, the metabolic product of some of the deepest sedimentary microbiomes, can be a biosignature and potential marker for the limit of life in the subseafloor environment. IODP Expedition 370 drilled 1.18 km into the Nankai Trough (Site C0023A) off Cape Muroto in Japan to define the extent of the biosphere in marine sedimentary basins. Sediment temperature here increases from 2°C to 120°C with depth, encompassing the upper temperature limit for microbial life. Additionally, the site contains a major tectonic and stratigraphic boundary at ~600 m depth, with relatively organic-rich trench deposits overlying organic-poor mudstone and tuff from up to 16 million years ago [1]. The upper strata contain high concentrations of ^{13}C-depleted methane, characteristic of microbial sources, while the lower strata contain low concentrations of ^{13}C-enriched methane, suggesting a thermogenic origin.

To better define the transition from microbial to thermogenic methane and to examine the source of thermogenic methane, we measured $\delta^{13}C$, δD, $\Delta^{13}CH_3D$, $\Delta^{12}CH_2D_2$ and the apparent methane equilibrium temperatures of both headspace (190.4 to 1109.9 mbsf) and void gas (206.9 to 361.0 mbsf) samples from Site C0023A, where both thermogenic and microbial methanogenesis have been proposed [2]. These datasets capture the geologically complex region defined by a trench-basin transition, the associated accretionary heating [3], and high variability in dissolved methane concentration and microbial population [4]. Isotope data suggests a potential transition from a primary microbial source (below ~60°C) to a thermogenic source (above ~80°C). Comparing void gas and headspace isotopic compositions helps advance the understanding of the effect of degassing during core recovery on methane isotopes. Paired with basal sediment accretion analysis, these data provide new constraints on the isotopic signatures and equilibrium stage of methane at subduction boundaries and provide insight into microbial energetics and metabolism near the temperature limit of life.

[1] Moore et al. (2001), *Proc. ODP, Init. Repts.,* 190: College Station, TX (Ocean Drilling Program).

[2] Taira et al. (1991), *Proc. ODP, Init. Repts.,* 131: College Station, TX (Ocean Drilling Program).

[3] Suzuki et al. (2024), *Communications Earth & Environment*, *5*(1), 1–10.

[4] Heuer et al. (2020), *Science*, *370*(6521), 1230–1234.