

METHANE FORMATION AND ITS ISOTOPIC ALTERATION AT TWO ACTIVE DEEP OCEAN COLD SEEPS FROM THE SCOTIAN SLOPE OF ATLANTIC CANADA

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Deep sea cold seeps occur along continental margins across the globe. The fluids escaping from these seafloor features can be rich in hydrocarbons and are an important component of Earth's carbon cycle. Cold seeps on the Scotian Slope of Atlantic Canada overlie a complex subsurface geology of reservoir and source rocks that are disrupted by allochthonous salt bodies. For this study, we compare industry 3D seismic data, ocean and basin heat flow estimates, and gas geochemical data collected from a 2021 ROV push core survey to better constrain the source of methane generation and its linkage to salt tectonism. Root mean square amplitude and coherence attribute maps focusing on the upper 3km of two large 3D seismic cubes show seismic anomalies approximately 300–400m below the seafloor. These interpreted direct hydrocarbon indicators represent trapped hydrocarbons that often appear centered over salt diapirs. Prior heat flow surveys across the area indicate elevated ocean bottom temperatures above salt structures. Hydrocarbon gas (methane, ethane, and propane) sampled at several seep sites overlying these DHIs within the 3D seismic surveys were captured using three different sample methods: *i*) ocean floor bubbling seep gas collected via a custom designed non-isobaric gas sampler, *ii*) void gas pockets extracted by drilling through the push corer liner, and *iii*) push core sediment headspace gas. The gas from each method was then measured for carbon and deuterium as well as methane clumped isotopic compositions ($\delta^{13}\text{C}-\text{CH}_4$, $\delta^2\text{H}-\text{CH}_4$, and $\Delta^{13}\text{CH}_3\text{D}$) for two active seeps having differing discharge rates. The gas speciation, as well as the bulk carbon isotopic and clumped isotopic data, unambiguously indicate the methane is generated by microbial carbonate reduction. The clumped isotopic values of directly sampled seep gas empirically match derived isotopic equilibrium values indicating their calculated methane formation temperatures reflect the original source location of the gas. Based on the above results, we