Abiotic hydrocarbon synthesis using a hydrothermal flow reactor: Implications of the C1/C2 ratio

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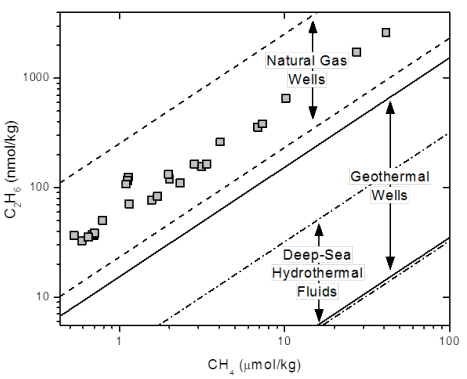
Mechanisms and potential catalytic effects influencing the abiogenic synthesis of hydrocarbons in natural hydrothermal systems are still largely unknown. Using an experimental flow through apparatus, including consecutive Ti and Au hydrothermal cells, we have observed CH_4 (C1) and C_2H_6 (C2) formation from precursor (aqueous) CO_2 and H_2 at 221 bars and 225 – 374°C. At any given temperature, yields increased linearly with residence time for both species, demonstrating they were still far from equilibrium at the lowest flow rates employed. However, a statistically meaningful increase in the C1/C2 ratio was observed with increasing temperature. Broadly speaking, the experimental C1/C2 ratios are consistent with those observed in natural gas wells and, unexpectedly, lower than those observed in both geothermal wells and deep-sea hydrothermal fluids.



The flow through design makes easily avoidable potential ambiguity regarding organic contamination; and C1-C2 formation rates do not appear independnent. Therefore, the low C1/C2 ratios require exploration of a multitude of other explanations. For example, one possibility is initial formation rates are simply not consistent with equilibrium values, with potential implications for any catalytic processes. Conversely, the higher C1/C2 observed in natural hydrothermal systems may reflect higher formation temperatures, consistent with those suggested by CO_2-CH_4 isotope systematics (e.g., ~600 – 800°C, though inconsistent with thermodynamic predictions).