

## Formation mechanisms for abiotic hydrocarbons

NIVEDITA THIAGARAJAN AND JOHN EILER

California Institute of Technology

Presenting Author: [nivedita@caltech.edu](mailto:nivedita@caltech.edu)

Abiotic formation of small (4 and fewer C atoms) *n*-alkane hydrocarbons has been suggested to occur on Earth. These hydrocarbons have been distinguished from microbial and thermogenic hydrocarbons based on their molecular proportions and carbon and hydrogen isotopic abundances. However, these methods can lead to ambiguous results where gases can appear to be abiotic by one index and not by others. Additional constraints are called for, as the ability to distinguish between sources of hydrocarbons is key to many problems in the global carbon cycle, the distribution of subsurface life, and the origin of life on Earth and other planets.

Abiotic hydrocarbons have been proposed to form in natural environments through Fischer-Tropsch-type (FTT) synthesis reactions. However, FTT reactions have been difficult to characterize as experiments run under subtly different conditions yield products with discrepant isotopic characteristics. We compile data for the molecular and isotopic components in FTT experiments and find that they exhibit two noteworthy characteristics; a distinctive disequilibrium signature seen on short timescales (<1-10 hour) and in low temperature (<300°C) experiments, and an approach to equilibrium seen on longer timescales (~1+ hour) and/or high temperature (>350°C) experiments. These findings suggest that intermolecular carbon isotope equilibrium can be a signature for products of FTT synthesis reactions occurring for long time scales and at hot temperatures, while decreasing  $d^{13}C$  values with increasing carbon number can be a signature for cool temperature and fast FTT reactions.

We then compile 119 samples from 17 different geographic locations that have previously been identified as abiotic gas fields, including volcanic gases, hydrothermal systems, fracture networks in crystalline rocks and serpentinization products. We find that hydrocarbons in these systems can be explained by 3 different formation mechanisms: metastable equilibrium processes at hot (~250°C+) temperatures; kinetically controlled cracking of long chain hydrocarbons; and an abiotic process producing a non-equilibrium isotopic signature that corresponds to relatively cool (<300°C) and brief (~1-10 hours) Fischer-Tropsch laboratory experiments. We can use these abiotic signatures as a method for distinguishing origins of hydrocarbons formed in a variety of settings, such as the deep earth or extraterrestrial environments.