Tracking the development of hydrocarbons on the surface of magnetite

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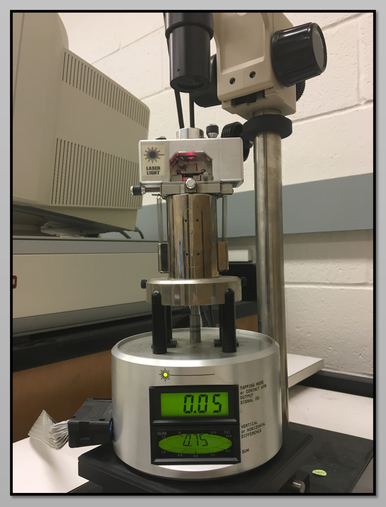
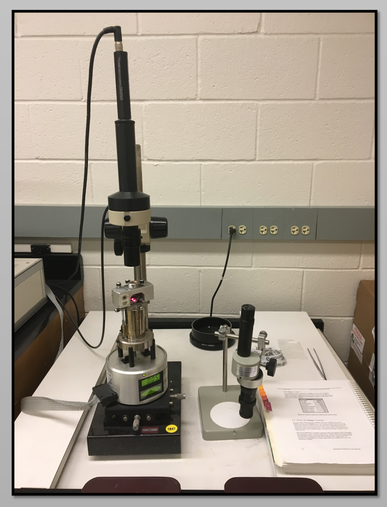
Background

- Primitive life could have originated from inorganic sources at hydrothermal vents.
- Magnetite could be the canvas on which hydrocarbons form on earth and possibly other planets.
- Visual evidence for the formation of such organic compounds is lacking and obtaining it requires a reliable method.

Methodology

- Use of an atomic force microscope (AFM) could provide “before and after” pictures to clearly show the growth of hydrocarbons.
- However, the AFM is challenging to use and often malfunctions.
- Capturing volatile gas products from an experimental apparatus also proves hydrocarbons are forming.

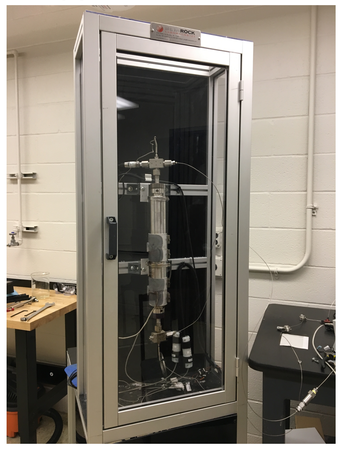




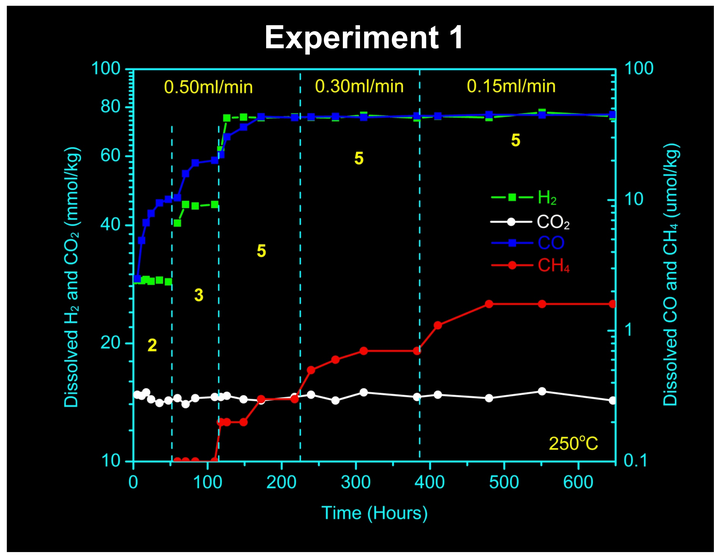
Atomic Force Microscope

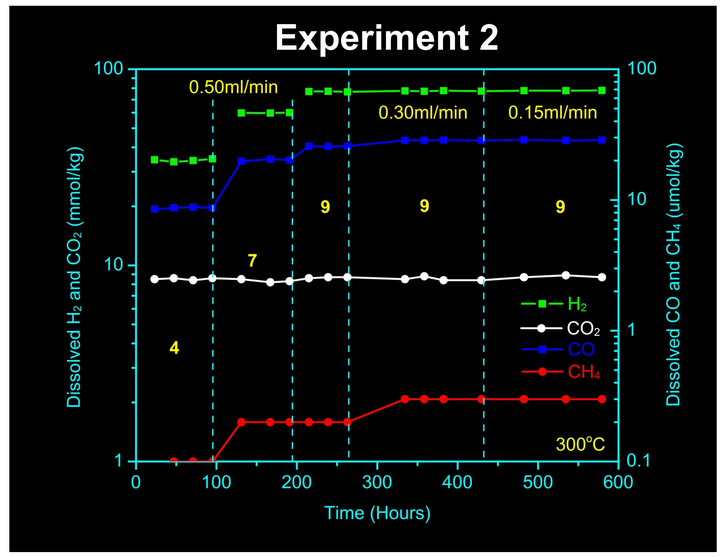
Results

- The AFM that was supposed to take the images is severely outdated and a more modern AFM was needed to continue the experiment. Unfortunately, even the new AFM was not able to work with our magnetite, but only because our sample was in powdered form.
- A separate experiment introducing carbon dioxide and hydrogen gas to the magnetite was able to provide data that supports the idea that hydrocarbons can emerge from inorganic sources.



- Fischer-Tropsch type reactions allow inorganic carbon and hydrogen to form hydrocarbons while in the presence of a catalyst and high temperature and pressure conditions.
- Such conditions mimic hydrothermal environments and the magnetite serves as a mineral catalyst in the reaction (occurring in the instrument to the left).
- Volatile carbon monoxide and methane were generated from the reactions.
- Experiment 1 was run at 250° C and 250 bars.
- Experiment 2 was run at 300° C and 250 bars.
- The diagrams below show that amounts of methane increased in two experiments under different physical and chemical conditions.





Fu et al. (2018) Experimental study of generation kinetics for abiotic methane in hydrothermal systems. *Goldschmidt conference 2018*.

Conclusions

Both experiments showed increased volatile methane, the simplest hydrocarbon. An increase in methane suggests that with the right conditions, hydrocarbons can form from inorganic sources such as carbon dioxide and hydrogen gas. Hydrothermal vents possess high temperatures and pressures, mineral catalysts, and sources of hydrogen and carbon, making them ideal environments for prebiotic synthesis. A different method of providing visual evidence of hydrocarbon formation is needed, possibly involving X-ray Photoelectron Spectroscopy (XPS) or a Secondary Ion Mass Spectrometer (SIMS). These two methods would provide information on a sample’s atomic structure which would reveal the presence of hydrocarbons.

Acknowledgements
Qi Fu, Xueze Chen, and Dylan Walther

References

Fu et al. (2007). Abiotic formation of hydrocarbons under hydrothermal conditions: Constraints from chemical and isotope data. *Geochimica Et Cosmochimica Acta,71*(8), 1982-1998.