Amorphous Iron Silicate Grains as Catalysts for Organics in the Solar Nebula

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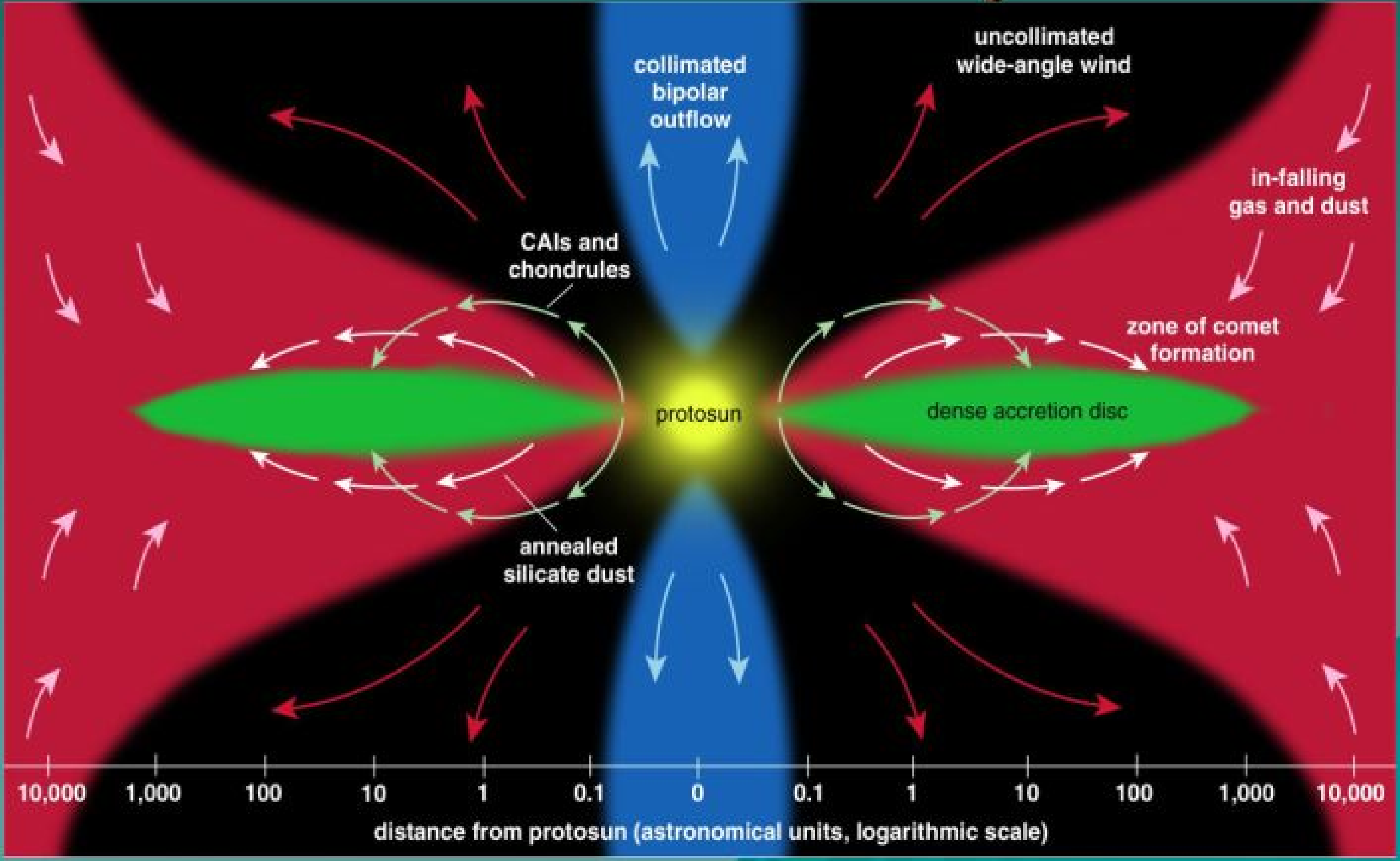
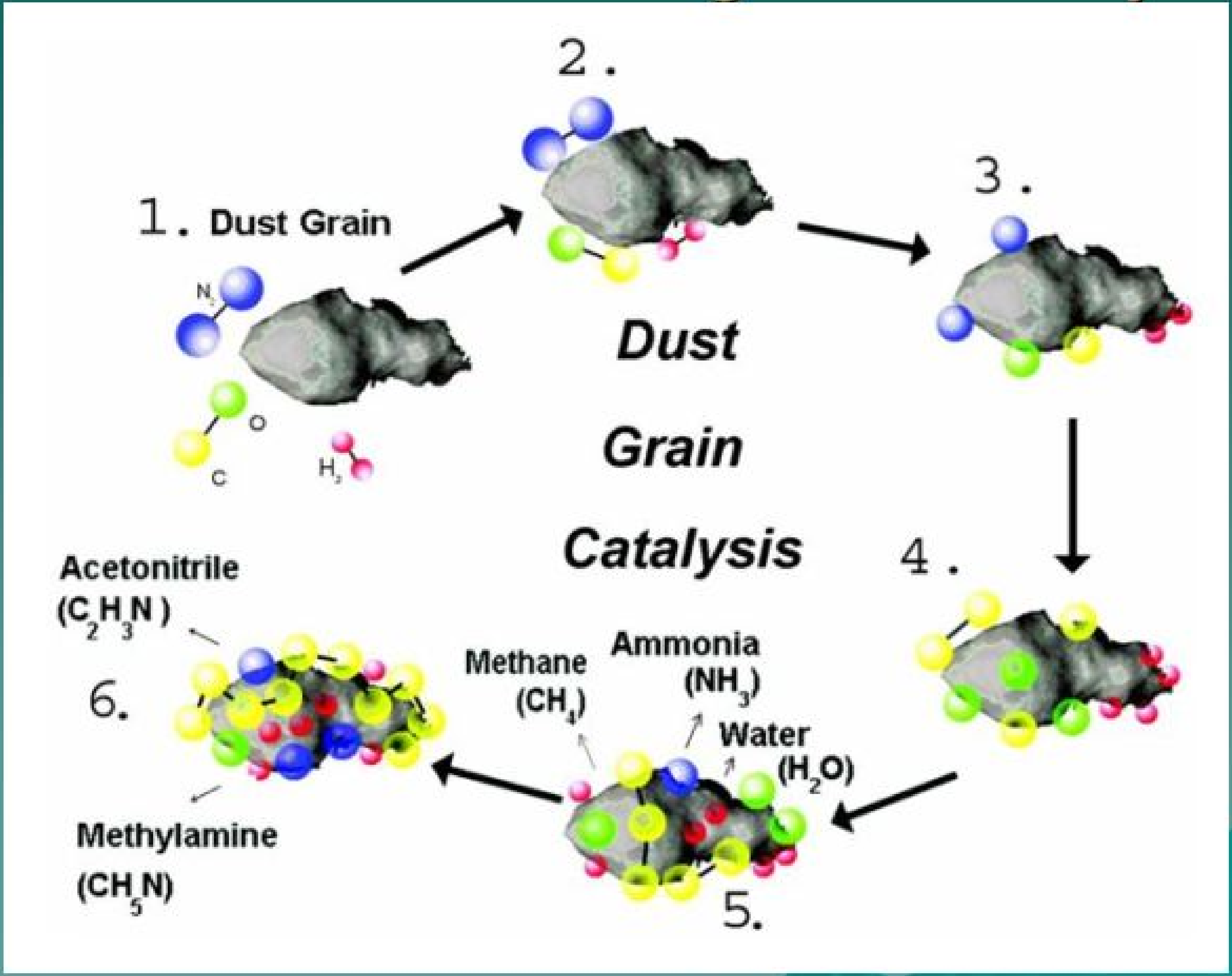
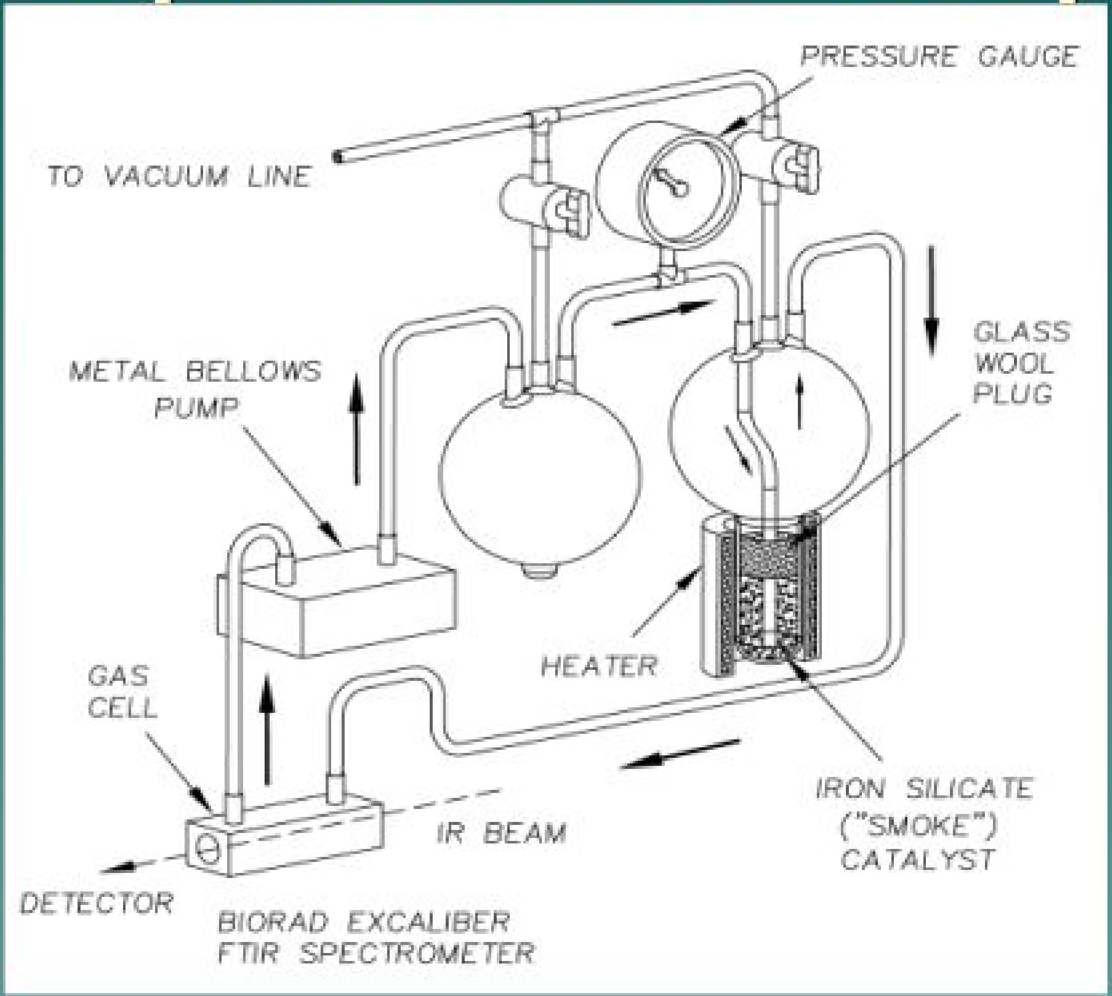
The Solar Nebula as an Organic Chemical Factory



Iron Silicates as Organic Catalysts

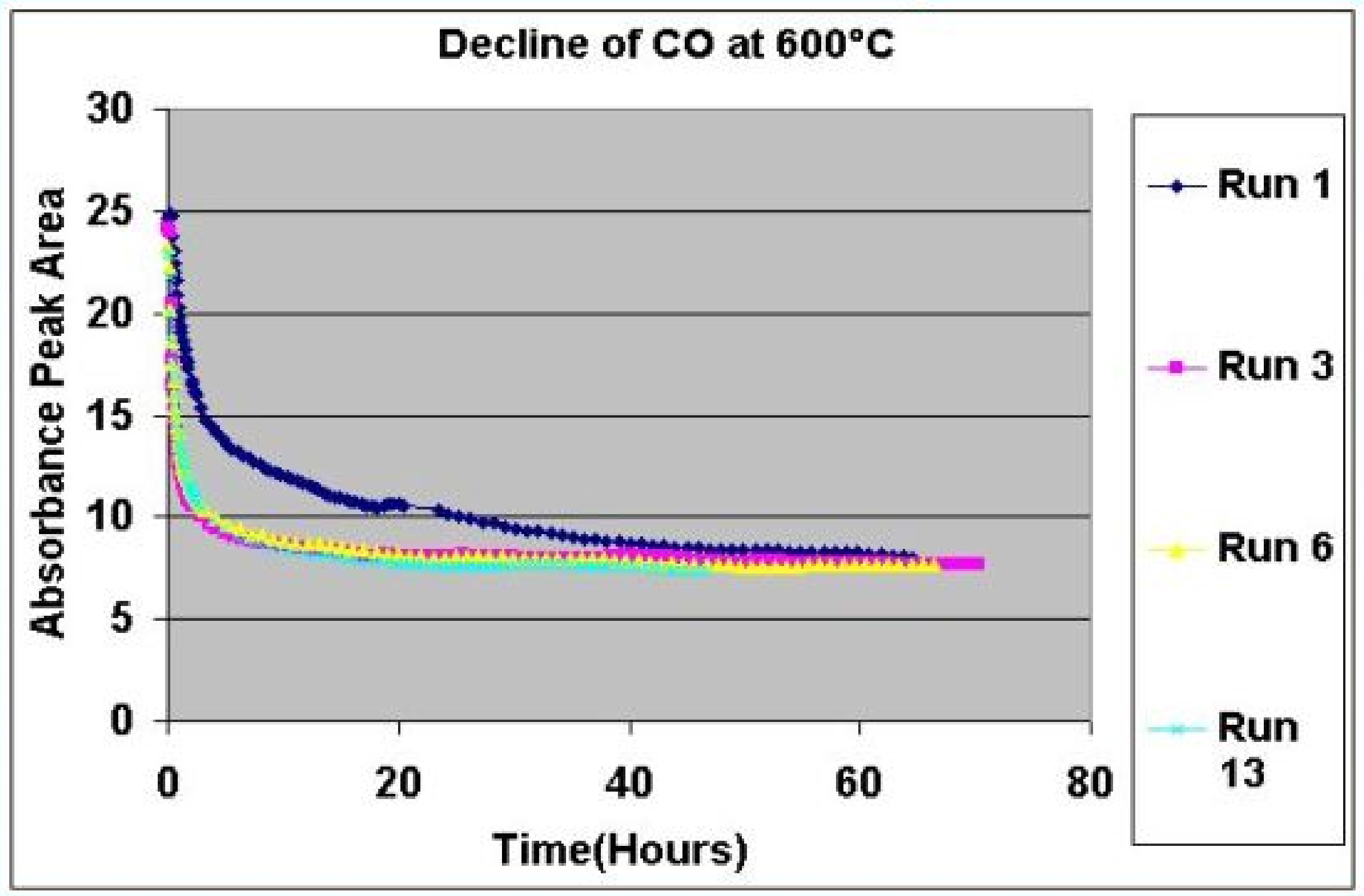


Experimental Set Up



- My Objective: Conduct experiments to determine the catalytic rates of the carbonaceous deposits on the iron silicate smokes, as compared to the rates of the iron silicate smokes themselves, in a laboratory environment.
- Importance to Astrobiology: Determine rates for forming important, possible prebiotic organics in the Solar Nebula

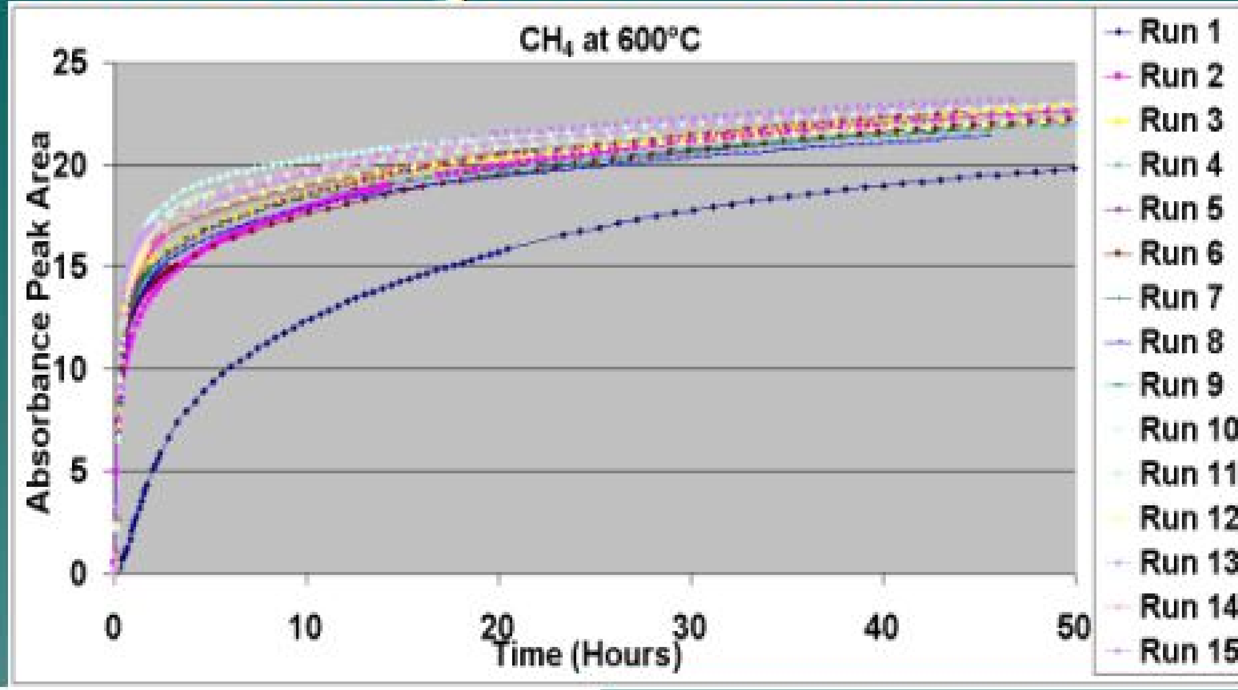
The most significant rate changes occurred in the first two hours of the experiments

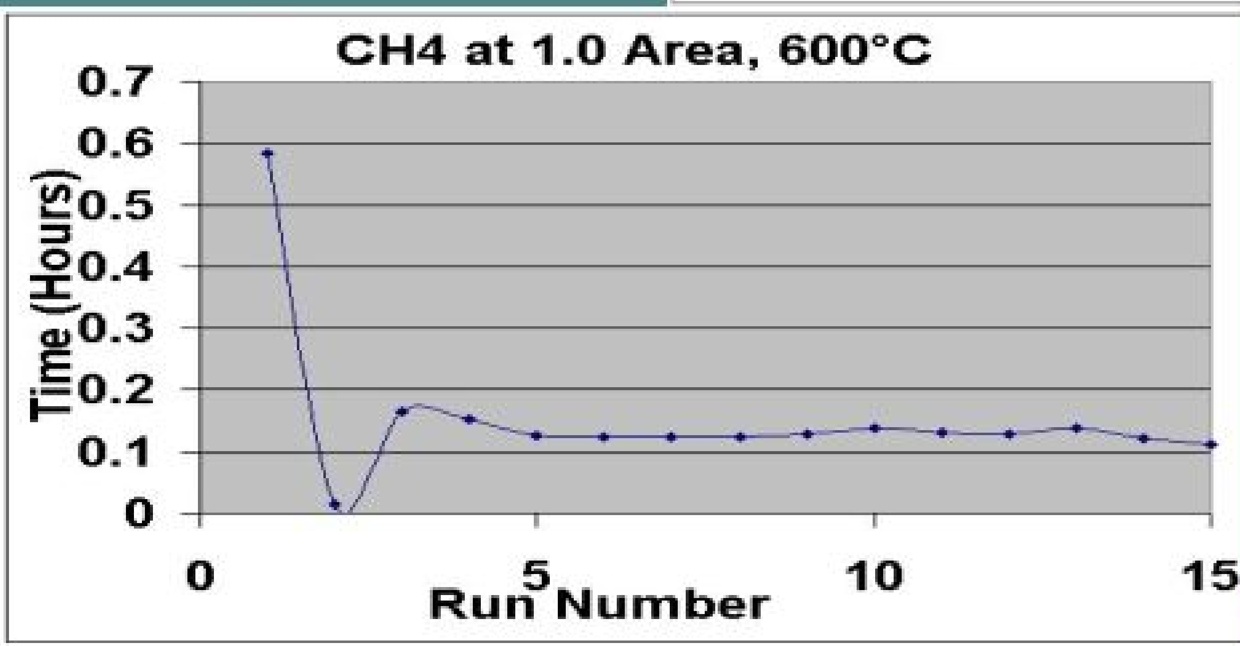


- As the grains became coated with residue, CO reacted faster to produce organic products at an increasing rate and in greater quantities

Analysis of the Catalytic Processes

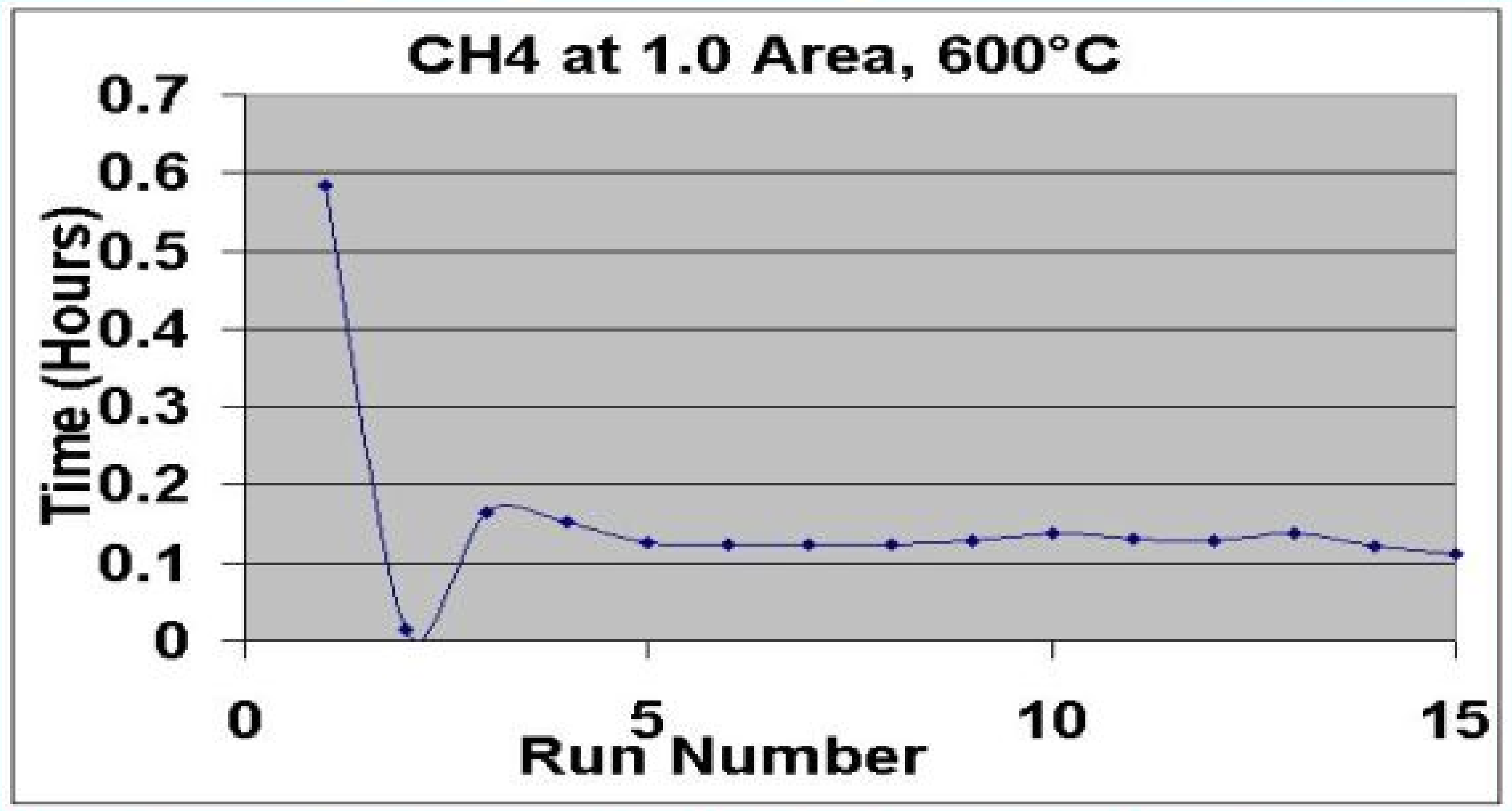
- The abundances of each specific product in all runs were plotted on one scale for each reaction temperature.





The time taken to reach an arbitrary level of product yields a rough estimate of the catalytic rate constant.

Changing Catalytic Processes

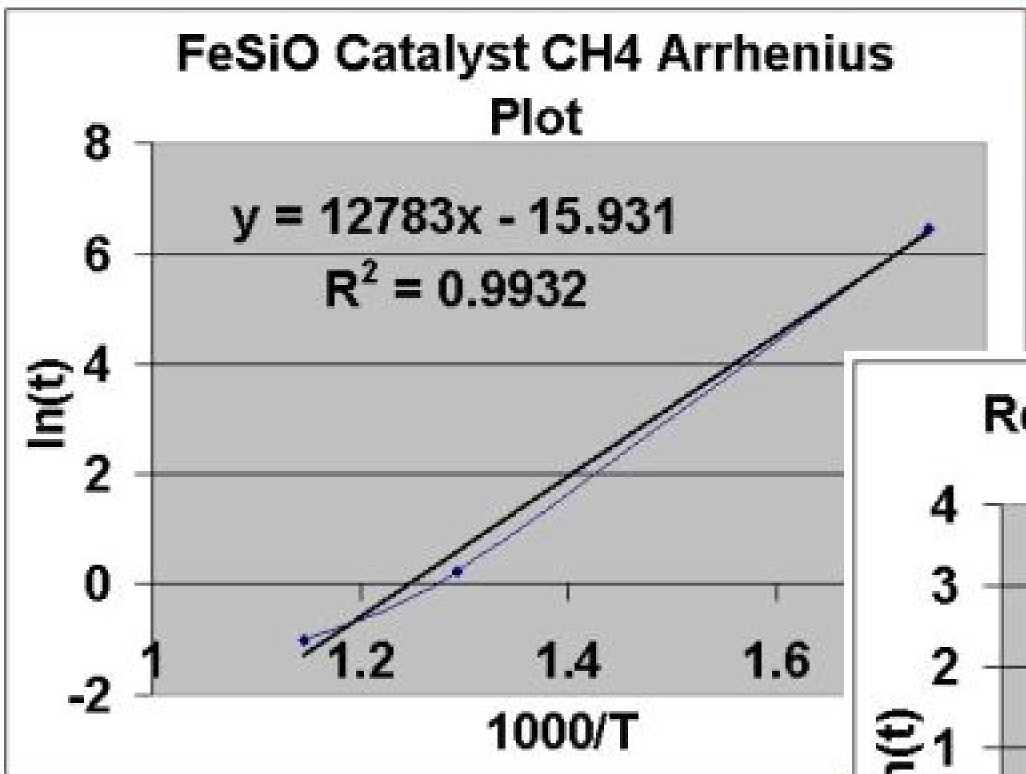


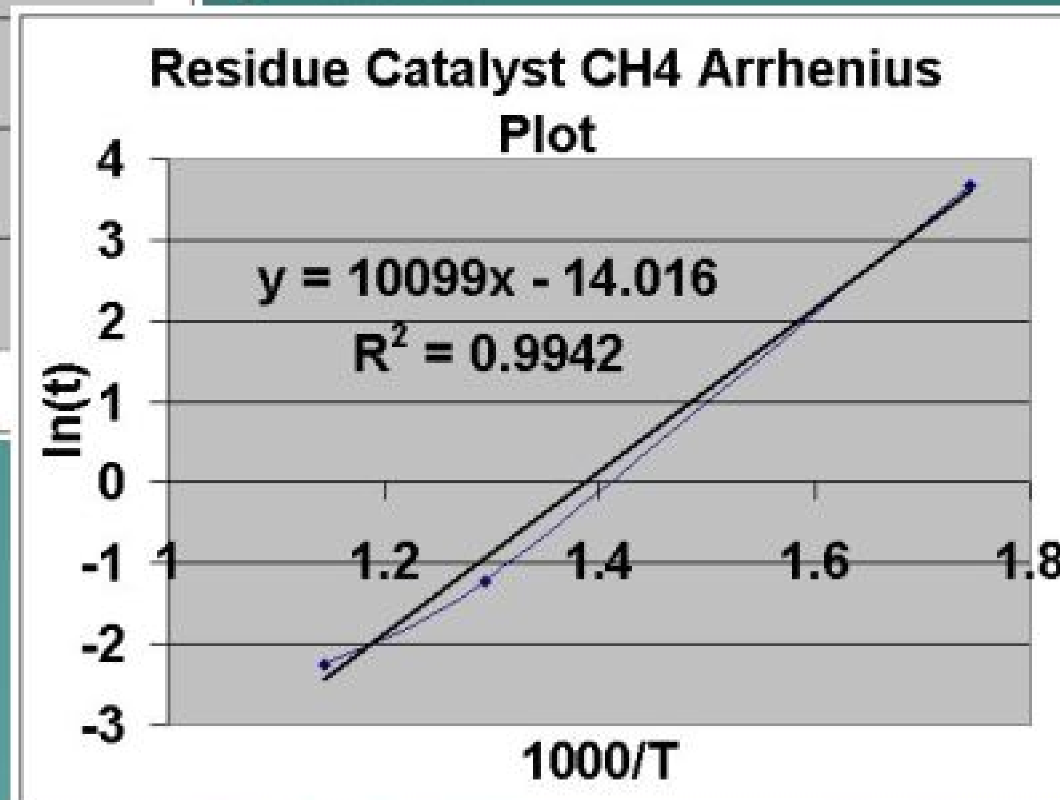
Each set contains an initial drop in the time required to reach a specific point in the reaction (initial catalysis by uncoated silicate grains) followed by a steady rate (due to catalysis by carbonaceous grain coatings).

Similar plots were made from runs at 300 & 500°C

Determination of Activation Energies

We used the Arrhenius Equation to determine the activation energies for each reactant and product.





$t = Ae^{-Ea/RT}$

$\ln(t) = -E_a/RT + \ln(A)$

slope = $-E_a/R$

intercept = $\ln(A)$

Activation Energies for Organics Studied

Compound	E_a FeSiO Catalyst (kcal/mol)	E_a Organic Residue Catalyst (kcal/mol)
CH_4 (product)	25.40	20.07
CN (product)	22.63	18.01
CO (reactant)	18.35	25.48

- Activation energy differed by catalyst

Conclusions

- **Iron Silicate grains provide an initial catalytic surface for organic compound production from CO, N_2 & H_2.**
- **A carbonaceous coating forms on the silicates after repeated exposure (~2^{nd} to 3^{rd} flush of reactive gases).**
- **The organic coating formed but did not stop catalysis: the rate was even greater than that of the clean silicate grains.**
- **The catalytic nature of the organic coating allows for further production of important, possible prebiotic organics throughout the Solar Nebula even well after the silicate grains become coated since the coating is actually a better catalyst than the original grains.**

Future Directions and Acknowledgements

- Further experiments analyzing the impact of many other environmental variables (pressure, gas mixture, grain composition, etc) are needed, as is analyses of the properties of the carbonaceous coatings produced in such settings.
- Analytical analysis of the organic deposits from the current experiments (abundances, isotope ratios) is now under way.

- Thanks to Joe Nuth, Hugh Hill, Kathryn Gardner, Michelle Steiner and Natasha Johnson for carrying out previous experiments at lower temperatures in this series.
- Thanks to Dr. Michael Mumma and the SUIA program for the support to carry out this research project.