SIMULATION OF PREBIOTIC EARLY EARTH HYDROTHERMAL CHIMNEY SYSTEM IN A THERMAL GRADIENT ENVIRONMENT. N. Hermis[1]*, L. M. Barge[1], G. LeBlanc[2], S. Perl[1], K. Chin.[1] [1]NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA; [2]The University of Tulsa, 800 S Tucker Drive, Tulsa, OK, USA (*ninos.y.hermis@jpl.nasa.gov)

Introduction: Hydrothermal chimneys are self-organizing chemical garden precipitates generated from geochemical disequilibria within deep-sea vent environments, and have been proposed as a possible setting for the emergence of life because they contain mineral catalysts and transect ambient pH/ E_h / chemical gradients. In sulfide-rich alkaline vent systems on the early Earth, chimneys would contain various metal sulfide minerals including iron sulfide [1], which is electrically conductive and reactive. These different gradients are all superimposed in a system that injects a heated fluid (containing e.g. sulfide-silicate) into a cold ocean environment. Such thermal gradients could affect the mineralogy, shape, and thermoelectric properties of the resultant metal sulfide precipitate. Thermal properties could affect the mineralogy within the chimney and thus its chemical reactivity [1]; thermoelectric properties induced by the temperature gradient [2] could also affect the electrical activity of the chimney mineral surfaces and thus be important to origin of life processes in an early Earth environment [3,4], and could also affect habitability since hydrothermal chimneys host microbes that uptake electron directly from mineral surfaces [5].

We successfully simulated the growth of hydrothermal chimneys in a thermal gradient environment within an early Earth vent system by using different hydrothermal simulants such as sodium sulfide which were injected into an early Earth ocean simulant containing dissolved ferrous iron. We developed an apparatus which can sufficiently cool the ocean simulant to near 0 °C in a condenser vessel immersed in a cold water bath while injecting a sulfide solution at hot to room temperatures, effectively creating an artificial chimney structure in a temperature gradient environment (**Δ**T) over a period of a few hours. Such experiments with different chemistries and temperatures gradients resulted in a variety of chimney morphologies.

Methodology: A glass vessel was filled with a 100 ml solution of a simulated early Earth ocean, containing 10 mM $FeCl_2{\cdot}4H_2O$; this vessel was then placed inside a 3D printed condenser that enveloped the glass vessel with an open top and open circulation pathway for fluids. The condenser was injected and cycled with near freezing water to cool the simulated ocean (pH ~ 6) [3] to approximately 5-10 °C. A syringe heater is heated to approximately 70-80 °C to raise the temperature of a variable concentration sulfide solution (representing a warm alkaline hydrothermal fluid) which is injected (Q = 2 ml/h) into the cold ocean. A thermistor is placed in the ocean to monitor and record all temperature data. The entire system is purged with argon gas to simulate an anoxic early Earth ocean.

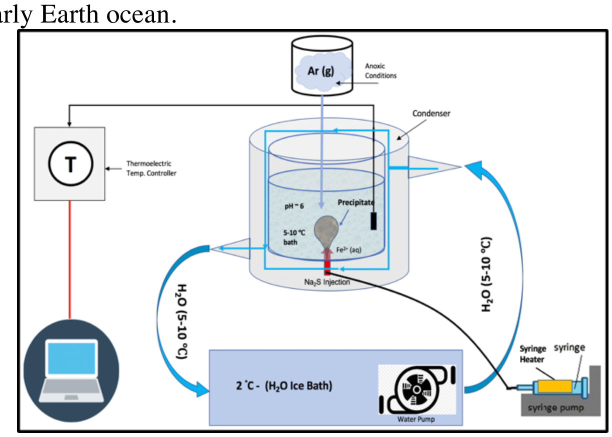

Fig. 1. Apparatus showing a cold ice bath circulated via a water pump through 3D printed condenser, enveloping a glass vessel containing the simulated Hadean Earth ocean. A hot sulfide solution is being injected at Q = 2 ml/h to construct a synthetic hydrothermal chimney.

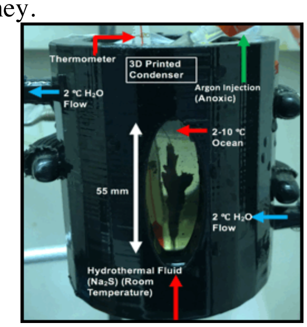

Fig. 2. 3D printed condenser enveloping a glass vessel showing growth of chimney precipitate.

Results / Future Work: Preliminary results show chimney growth of ~5 cm, and that chimney structure and growth processes are highly affected by temperature gradients. See figure 2. Future studies will include further testing of thermoelectric properties, chemistries and mineralogy in a wide range of environmental temperature gradient

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