Exploring Alkaline Hydrothermal Vent Environments for Abiotic RNA Polymerization. L. B. McGown[1,2], B. T. Burcar[1,2], L. M Barge[3], M. J. Russell[3], E. B. Watson[1,4], [1]New York Center for Astrobiology, Rensselaer Polytechnic Institute, Troy, NY 12180, USA, mcgowl@rpi.edu, [2]Department of Chemistry and Chemical Biology, Rensselaer Polytechnic Institute, Troy, NY 12180, USA, [3]NASA Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena CA 91109, USA, [4]Department of Earth and Environmental Sciences, Rensselaer Polytechnic Institute, Troy, NY 12180, USA

Introduction: Living organisms process chemicals from their environment to create their biological machinery and replicate their genetic material. While modern organisms generally utilize a combination of DNA, RNA, and proteins to conduct metabolism and replication, it is possible that organisms could have existed in Earth's history in which RNA was the primary molecule to conduct these biochemical processes, relying upon its unique ability to serve as both a genetic template and a biochemical catalyst. Emergence of such an "RNA World" on the early Earth would require mechanisms for polymerization of monomeric ribonucleotides under prebiotic conditions. Significant effort has been directed toward identification of such mechanisms, primarily in neutral aqueous solution, and in natural and laboratory analogs of plausible surface environments of early Earth. Continuing the search for plausible pathways to RNA polymerization on early, prebiotic Earth is a vital step toward understanding the role of RNA in the origin and early evolution of life.

Here we explore abiotic RNA polymerization in laboratory analogs of deep ocean, hydrothermal vent systems formed under conditions consistent with our current understanding of early Earth [1]. In this scenario, venting of reduced, sulfide-containing alkaline fluids into acidic, anoxic, ferrous-containing ocean waters would have led to the formation of hydrothermal "chimney" precipitates containing diverse minerals such as iron/nickel sulfides, double layer oxyhydroxides, silicate clays, and carbonates. Laboratory simulations of these prebiotic hydrothermal chimneys have been shown to exhibit a high degree of self-organization and provide micro-scale compartmentalization to facilitate sequestration and concentration of organic molecules from the local environment into micro-environments rich in catalytic, hydrothermal minerals conducive to prebiotic chemistry [2-6].

RNA polymerization in simulated Fe-S chimneys. Our simulated hydrothermal chimneys were formed using injection chemical garden experiments [1,2,7] to anaerobically synthesize iron-sulfide precipitates under different chemical conditions. Polymerization of adenosine 5'-monophosphate (AMP) and imidazole-activated AMP was studied in the absence and presence of montmorillonite clay. Montmorillonite is a phyllosilicate clay produced by water-rock interactions and thought to be present on the early Earth. Its ability to catalyze polymerization of imidazole-activated nucleotides in aqueous solution is well known (e.g. [8]).

In situ nucleotide activation. A limitation of much of the work on abiotic RNA polymerization has been the reliance upon pre-activated nucleotides that are synthesized in organic solvents under carefully controlled conditions. In order to achieve a more realistic activation pathway, we investigated an alternative scheme in which the same activated nucleotides are produced *in situ* in the polymerization reaction. The success of this scheme has been demonstrated in simple, aqueous solution [9] and provides additional support for the feasibility of abiotic pathways to an RNA World.

Implications: The results of these studies demonstrate that abiotic RNA polymerization is more robust than previously thought, occurring under previously unexplored chemical conditions in complex heterogeneous structures that may have been common on the early Earth. The synthesis of RNA oligomers in deep ocean, hydrothermal vent environments energetically favorable to life on the early Earth [3] would be advantageous to emergence of an RNA World. More generally, the potential to achieve abiotic polymerization of *in situ* activated ribonucleotides, in diverse environments consistent with the early Earth, increases the likelihood of involvement of RNA in the emergence and early evolution of terrestrial life.

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