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White and green rust chimneys accumulate RNA in a ferruginous chemical garden

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Mechanisms of nucleic acid accumulation were likely critical to life's emergence in the ferruginous oceans of the early Earth. How exactly prebiotic geological settings accumulated nucleic acids from dilute aqueous solutions, is poorly understood. As a possible solution to this concentration problem [1], we simulated the conditions of prebiotic low-temperature alkaline hydrothermal vents in co-precipitation experiments to investigate the potential of ferruginous chemical gardens to accumulate nucleic acids via sorption. The injection of an alkaline solution into an artificial ferruginous solution under anoxic conditions (O_2 <0.01% of present atmospheric levels) and at ambient temperatures, caused the precipitation of amakinite ("white rust"), which quickly converted to chloride-containing fougerite ("green rust"). RNA was only extractable from the ferruginous solution in the presence of a phosphate buffer, suggesting RNA in solution was bound to Fe^{2+} ions (Figure 1). During chimney formation, this iron-bound RNA rapidly accumulated in the white and green rust chimney structure, as it was depleted from the surrounding solution (Figure 2). Our findings reveal that in the oceans of the early Earth, white and green rust chimneys were likely key geochemical features that can rapidly sequester and accumulate RNA [2]. This represents a new mechanism for nucleic acid accumulation, in addition to wet dry cycles, and may have promoted RNA survival in a dilute prebiotic ocean.

[1] De Duve (1991), Blueprint for a Cell: The Nature and Origin of Life.

[2] Helmbrecht, Weingart, Klein, Braun, Orsi (2022), White and green rust chimneys accumulate RNA in a ferruginous chemical garden. arXiv preprint arXiv:2212.02793.

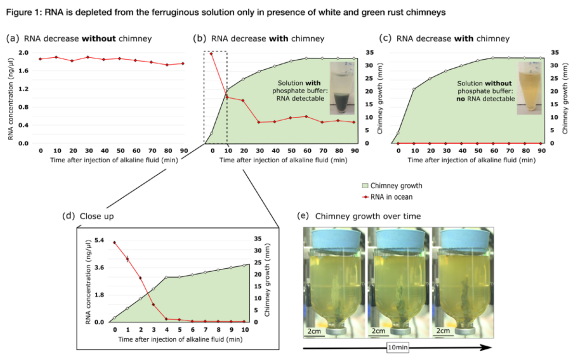

Figure 2: Accumulation of RNA in the white and green rust chimney structure