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Thermally Driven Accumulation and Dry-Wet Cycles of Nucleotides

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Introduction: Life has developed in water, but dry steps are essential for many prebiotically plausible syntheses and polymerization processes [1,2]. This posits the question how dry-wet cycles can be combined in a single scenario without diluting reaction products into the ocean.

We found that a nonequilibrium system in form of a temperature gradient across submerged porous rock creates an environment where molecules accumulate both in water and at water-air interfaces [3]. The presence of an interface in the pores results in continuous drying and re-hydration steps of the molecules at the interface. This provides intermediate dry state phases while maintaining high local concentrations of ca. 1000-fold in the aqueous phase. Importantly, even without the interface molecules such as RNA monomers can be concentrated above their limit of solubility, leading to precipitation.

Here, we show the underlying mechanisms for the accumulation process both at the bottom of the pore and at the water-air interface. In both cases a precipitation of diluted molecules can be observed. These mechanisms potentially enable reaction pathways such as the formation, phosphorylation, or polymerization of nucleotides that require aqueous and dry conditions.

References: [1] Powner MW, Gerland B, Sutherland JD (2009) *Nature* 459:239-242. [2] Morasch M. et al (2014) *ChemBioChem* 15:879-883. [3] Liu J, Morasch M, Braun D (*in submission*)

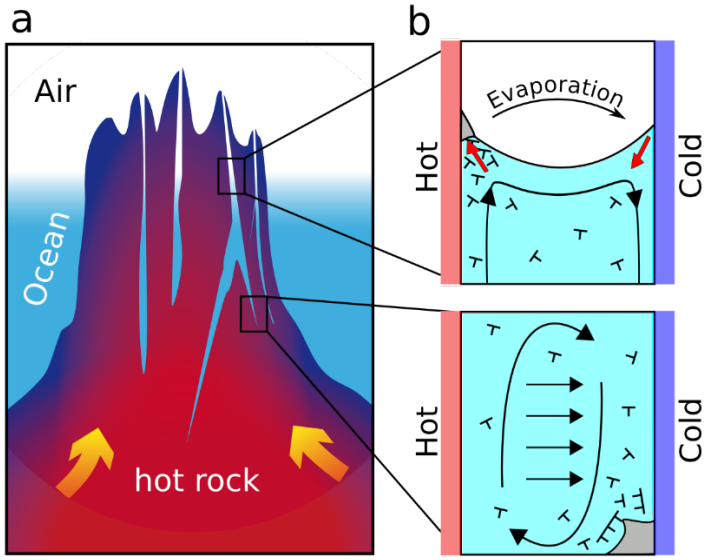

Figure 1 – Accumulation processes in submerged porous rock. a) Hot water emerging from porous rock in e.g. volcanic or steam settings. b) Top: Air-water interfaces formed e.g. by bubbles inside the rock or partial exposure to the atmosphere. The temperature gradient causes convection while simultaneously evaporating water at the hot side and condensing at the cold side. Molecules are thereby strongly accumulated at the hot side of the interface (see arrows), leading to dry phases. Bottom: A combination of convection and thermophoresis results in an accumulation of molecules at the bottom of the pore. Local concentrations can exceed the solubility limit, causing the molecules to precipitate.