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Microfluidic Quasi-2-Dimensional Alkaline Vent Model to Study Precipitation Morphology, Fluid Flows and Molecule Accumulation

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Alkaline vents facilitate the precipitation of warm, alkaline fluids exhaled into slightly acidic ocean water, thus providing the necessary gradients to drive molecular reactions at the Origins of life. The 3D chimney-like structure of the precipitates, however, prevented any visualisation and testing of potentially reaction fueling gradients to date.

We develop a quasi-2-dimensional microfluidic model of alkaline vents that allows spatio-temporal visualisation of the iron-mineral formation process. To simulate the vent conditions an alkaline fluid is injected into an acidic, Fe(II)-rich solution inside a thin chamber of 500µm thickness. Under variation of flow-rate and ion-concentration of the fluids, we observe a diverse set of precipitate morphologies. Using microscope imaging and pH dependent dyes, we show that disordered, fingered precipitates can facilitate formation and maintenance of pH gradients on the microscale and accumulation of dispersed particles in confined geometries.

Our model is established to investigate the potential of microscale gradients across a semi-permeable boundary for early compartmentalisation, accumulation and chemical reactions at the origins of life.