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Pumice as a remarkable substrate for the origin of life

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The context for the emergence of life on Earth at sometime prior to 3.5 billion years ago is almost as big a puzzle as the definition of life itself. Hitherto, the problem has largely been addressed in terms of theoretical and experimental chemistry plus evidence from extremophile habitats like modern hydrothermal vents and meteorite impact structures. Here, we use new field and laboratory evidence, including that from some of the Earth's oldest sedimentary rocks, to argue that extensive rafts of glassy, porous and gas-rich pumice could have played a significant role in the origin of life. This is because pumice has four remarkable properties. First, during eruption it develops the highest surface-area-to-volume ratio known from any rock type. Second, it is the only known rock type that floats as rafts at the air-water interface and then becomes beached in the tidal zone for long periods of time. Third, it is exposed to an unusually wide variety of conditions, including dehydration. Finally, from rafting to burial, it has a remarkable ability to adsorb metals, organics and phosphates as well as to host organic catalysts such as zeolites and titanium oxides. As an example of testing this hypothesis, we here examine pumice from the $\sim$3,460 Ma Apex Basalt of Western Australia, and the $\sim$1,878 Ma Gunflint Formation of Ontario, Canada. Textural and geochemical analysis – including NanoSIMS - of these deposits reveal, for the first time: concentrations and intimate associations of biologically-important elements (C, H, O, N, P and S); vesicles lined with catalysts such as titanium oxide and iron sulfide; and vesicles lined with phosphate minerals. We take these to indicate that pumice, and especially floating and beached pumice rafts, may have provided an ideal environment for the growth of biominerals both within and around the pumice vesicles; and for the adsorption and catalysis of hydrocarbons from volcanogenic condensates or floating 'oily films'. This combination of hydrocarbons, biolimiting elements, catalysts and reactive surface areas, all placed within cell-like chambers at the air-water interface, seems truly intriguing.