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A hydrothermal-sedimentary origin of life scenario

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Abstract

Prebiotic chemistry leading to the emergence of life could have taken place in volcanic sediments flushed by hydrothermal fluids that were ubiquitous on the early Earth.

1. Introduction

Many locations, ranging from hydrothermal vents, pumice rafts, to continental springs and rivers, have been proposed for the emergence of life on Earth 1-3]. Hydrothermal edifices, in particular, offer a combination of characteristics that make them particularly attractive: concentration of organic molecules in the porous edifices, disequilibrium conditions and protection from harmful UV radiation, presence of transition metal-rich mineral surfaces upon which molecules can con-dense, be structured and complexify [4,5].

2. Results

Using evidence from the oldest, well-preserved volcano-sedimentary rocks (3.5-3.3 Ga), the best available analogues to Hadean sediments, we document from the macrosopic to the microscopic and elemental scale that these porous volcanic sediments (originating from mafic and ultramafic crust) were permeated by hydrothermal fluids at all scales, gently infiltrating between the pores or sometimes more dynamically mixing the volcanic particles (Figure 1 [6, 7]).

3. Discussion

Reduced carbon was brought in by the hydrothermal fluids although carbon of meteoritic origin would also have been relatively abundant, especially in the Hadean era. This UV-protected, subaqueous sedimentary environment, characterised by physical and chemical disequilibria (gradients in temperature, pH, redox and relatively diverse mineral speciation), represented a globally distributed system of miniature chemical reactors in which the production and complexification of prebiotic molecules could have led to the origin of life.

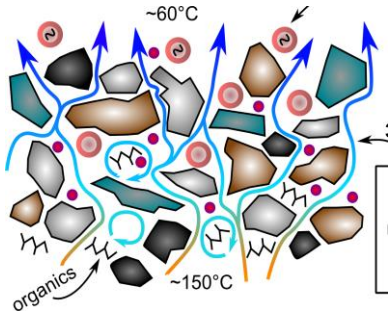

Figure 1. Prebiotic chemistry in hydrothermal volcanic sediments

4. Conclusions

The fundamental importance of these observations is that hydrothermal sediments and these kinds of organic reactions occurring at mineral interfaces must have been ubiquitous on the Ha-dean Earth, and life could have emerged anywhere all over the early Earth – at temperatures (<100°C) conducive to prebiotic chemistry.

References

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