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Deep Reaching Gas-permeable Tectonic Faults of the Early Earth as Habitats for the Origin of Life

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The discussion on the origin of life encounters difficulties when it comes to estimate the conditions of the early earth and to define plausible environments for the development of the first complex organic molecules. Until now, the role of the earth's crust has been more or less ignored. First continental crustal cores may have been developed some tens to hundreds of million years after formation of earth. Due to tectonic stress the proto continents were sheared by vertical strike-slip faults at an early stage. These deep-reaching open, interconnected tectonic faults may provide possible reaction habitats ranging from nano- to centimetre and even larger dimensions that sum up to several cubic kilometres for the formation of prebiotic molecules. Their fillings consist of supercritical and subcritical waters and supercritical and subcritical gases. Here, all necessary raw materials including phosphate for the development of prebiotic molecules exist in variable concentrations and in sufficient quantities. Furthermore, there are periodically changing pressure and temperature conditions, varying pH-values, metallic surfaces, clay minerals and a large number of catalysts. While cosmic and UV-radiation are excluded, nuclear radiation intervenes the chemical evolution of the molecules inside the crust. Carbon dioxide (CO_2) is of crucial importance. It can be present in an almost pure form as a supercritical fluid ($scCO_2$) in a crustal depth less than 1 km (critical point of pure CO_2: 74 bar; 31°C). Inside strike-slip faults, a two-phase system formed by supercritical CO_2 in liquid water provides the environment for condensation and polymerisation of hydrogen cyanide, nucleobases, nucleotides and amino acids. $ScCO_2$ is a non-polar solvent that is widely used in "green chemistry" (Anastas and Kirchhoff 2002) and enables the dissolution of non-polar reactants and their reactions normally occurring in the absence of water. Under the influence of periodically changing conditions (extreme earth tides played an important role for cyclic variations within the fluid-water-interface and for the development of gradients), the reaction products can be transferred into a neighbouring aqueous environment.
Based on these conditions, prebiotic molecules could have been condensed to long-chained molecules, from which first cell structures could have been formed by chemical evolution.
This hypothetical model for the origin of life can be used to design crucial experiments for the model's verification. Because all proposed processes could still occur in tectonic faults at the present time, it may be possible to detect and analyse the formation of prebiotic molecules in order to assess the validity of the proposed hypothesis. A clear indication of the geological provenience of corresponding organic substances arises, if these substances appear in racemic mixtures (e.g. d- and l-alanin), making them distinguishable from similar molecules of biological origin. Additionally, their isotopic composition can help to exclude a possible biological origin. Further on, the possible detection of these substances in fluid inclusions of quartz dykes of former deep crustal parts is another possible proof of the hypothesis.

Keywords: origin, life, strike-slip faults, $scCO_2$, prebiotic molecules

References

Anastas PT, Kirchhoff MM (2002): Origins, current status and future challenges of green chemistry. Acc Chem Res 35:686
Schreiber U., Locker-Grütjen O., Mayer C. (2012): Hypothesis: Origin of Life in Deep-Reaching Tectonic Faults. Origins of Life and Evolution of Biospheres (accepted 10.12.2011), Springer, Heidelberg