Minerals and rocks and the chemistry of life's origin

STEFAN FOX

Department of Bioinorganic Chemistry, Institute of Chemistry, University of Hohenheim, Stuttgart, Germany (correspondence: stefan.fox@uni-hohenheim.de)

Four billion years ago, chemistry on Earth gave rise to increasingly complex organic molecules, which initially formed reaction networks ("protometabolisms") that later evolved into the first living cells. At that time, already several hundred minerals were present on Earth [1]. In fact, results from laboratory simulation experiments suggest that minerals were important for organic chemical evolution in many ways.

Minerals can protect organic molecules against UV radiation, either by covering them or, in the case of layer silicates, by intercalating them into interlayer spaces. Minerals can also alter the reactivity of organic molecules. Intercalated glycine, for example, is thermally transformed to oligopeptides, in contrast to the non-intercalated amino acid, which forms a black polymer on heating [2, 3].

Besides silicates, some other minerals and inorganic salts are of interest to the topic of this talk. For example, magnetite is a potential catalyst in Fischer-Tropsch (FT) syntheses and interestingly a product of serpentinization. Both reactions could occur in deep-sea hydrothermal systems, which therefore have been suggested as sources of abiotic organic molecules. This view, however, has been challenged ("more sink than source"). Also controversially discussed is the iron-sulphur-world hypothesis, in which FeS, H_2S, and the formation of molecular hydrogen as reductant for organic molecules are central. It has been hypothesized that early precursors of metalloproteins obtained their metal ion cofactors from minerals. Similarly, abiotically formed porphyrins [4] may have extracted metal ions (e.g. Fe^{2+}) from minerals. The resulting metalloporphyrins might have been early functional analogues of modern proteins such as the cytochroms.

In addition, the hypothesis that minerals contributed to the origin of biological homochirality will be discussed. Prebiotic chiral molecules may have been enantioselectively adsorbed on, for example, quartz, which forms enantiomorphic crystals, and calcite, which forms scalenohedral crystals with mirror-image crystal faces.

To gain deeper insight into these interesting but complex issues, much more experimental research is needed.

[1] Hazen (2013) *Am. J. Sci.* **313***,* 807–843. [2] Fox *et al.* (2015) *Chem. Eur. J.* **21,** 8897–8904. [3] Dalai *et al.* (2016) *Orig. Life Evol. Biosph.* doi:10.1007/s11084-016-9523-0. [4] Fox and Strasdeit (2013) *Astrobiology* **13**, 578–595.