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Bio-Mediated Nitrogen Cycling in Serpentinisation: Metal Catalysis and Its Role in the Origin of Life and Geochemical Cycles

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Some theories of the origin of life on Earth consider that the alkaline and H_2-rich conditions found in serpentinites are essential for the genesis of life [1]. In these models, primitive organic compounds formed by metal-catalysed reduction of CO_2 and NO_3^- by H_2 [2]. Alternatively, the first organic compounds and life may have evolved from HCN produced by impactors [3]. However, few studies have established the spatial relationships amongst C- and N-bearing compounds and potential metal catalysts in serpentinites. Nanoscale imaging by Atom Probe Tomography (APT) and Time of Flight-Secondary Ion Mass Spectroscopy (ToF-SIMS) was used to detect these relationships. Mapping using ToF-SIMS reveals CN in native-Cu and partially dissolved chalcopyrite in sulphides and native Cu from the Wadi Tayin Ophiolite, Oman. APT analyses show Ag segregation along grain boundaries in native-Cu specimens. We developed a model where: (i) serpentinisation produces H_2 that reduces aqueous CO_3^{2-}- and NO_3^--bearing species to form reduced C and N; (ii) Cu catalysed the reduction of C and N, favouring the fixation of CN in native-Cu and chalcopyrite pores. The results provide insights into (a) the crust-mantle N cycle, (b) the spatial association between metal catalysts and reduced C- and N-species, and (c) the potential abiotic process that led to the origin of life.

References

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