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Mineral Electrolysis in the Origin and Evolution of Life

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Recent work on biological responses to marine electrolysis provides crucial new insights into the role of natural electrical currents in the origin and evolution of life throughout time. Electrical currents flowing down redox voltage gradients are the basis of universal biochemical energy metabolism, yet the roles of electricity in the origin and evolution of life have remained speculative. Natural electrochemical potential gradients between minerals in the primordial ocean, and in hot salty hydrothermal vents, are sufficient to structure voltage gradients that orient directional electrical current flows down redox gradients, which are essential for cellular structures and universal energy metabolism to evolve. Pyrite, one of the most common minerals in hydrothermal veins, plays a key role because of its very high electrical conductivity, focusing electrons and polar charged organic chemicals onto surface Iron-Sulfur bonds. Iron-Sulfur clusters are nearly universally used in biological electron redox reaction charge transfers and energy metabolism (Lane, 2015, 2022; Smith & Morowitz, 2016). The role of external currents in energy metabolism was only recognized recently from responses of marine organisms to external currents (Goreau, 2014, 2022). Sea water electrolysis creates energy flow through alkaline, hydrogen-rich environments analogous to primordial geothermal springs recycling water through hot crust, providing novel functional insights into biogeochemical conditions creating oriented structures and layers in the origin of life and its subsequent evolution. Stimulating natural biological responses with external currents greatly accelerates ecosystem growth, resistance to extreme environmental stresses, and regeneration of biomass, biodiversity, and ecosystem function. The need to maximize available biochemical energy from external electrical current flows is a fundamental, but previously unrecognized, evolutionary selective force stimulating evolution of membranes, redox metabolism, cells, symbiosis, cilia, multicellularity, and both sessile and motile life styles. Adaptations to natural electrical currents strongly affect trophic structure of marine ecosystems, especially coral reefs, and their ability to respond and adapt to extreme climate stresses (Goreau, 2023), and were later internalized to allow life on land. Sea water electrolysis applications may be crucial to save the most critically endangered ecosystems like coral reefs, mangroves, and seagrasses from climate change, and protect shorelines from erosion.