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The Limits of Life in the Deep Subsurface - Implications for the Origin of Life

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There are very few environments on Earth where life is absent. Microbial life has proliferated into habitats that span nearly every imaginable physico-chemical variable. Only the availability of liquid water and temperature are known to prevent the growth of organisms. The other extreme physical and chemical variables, such as pH, pressure, high concentrations of solutes, damaging radiation, and toxic metals, are life-prohibiting factors for most organisms but not for all. The deep subsurface environments span all of the extreme conditions encountered by life including habitat conditions not yet explored, such as those that combine high temperature, high and low pH and extreme pressures. Some of the "extremophile" microorganisms inhabiting the deep subsurface environments have been shown to be among the most "ancient" of extant life. Their genomes and physiologies have led to a broader understanding of the geological settings of early life, the most ancient energy pathways, and the importance of water/rock interactions and tectonics in the origin and early evolution of life. The case can now be made that deep subsurface environments contributed to life's origin and provided the habitat(s) for the earliest microbial communities. However, there is much more to be done to further our understanding on the role of moderate to high pressures and temperatures on the chemical and biochemical "steps" leading to life, and on the evolution and physiology of both ancient and present-day subsurface microbial communities.