

Biological and Biosignature Potential in Low Energy Flux Environments

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The presence of life on a given world does not guarantee that we can detect it. As Earth vividly demonstrates, some environments are more vibrantly inhabited than others, and some provide much richer evidence of that inhabitation. On Earth, sunlight and the direct products of photosynthesis provide such abundant energy for life that its distribution across Earth's surface is governed primarily by limitations in other resources, such as liquid water and nutrients. In the absence of photosynthesis and its products, the flux of biologically usable energy from the planet itself would be globally >6 orders of magnitude less than in its presence. Energy availability on habitable worlds elsewhere in the solar system may be better approximated by these million-fold smaller fluxes. The corresponding implications for biological and biosignature potential, which should be acknowledged in the development of life detection strategies, are explored in two example cases:

Biological potential. A cell-scale reactive transport model was used to quantify the metabolic potential of methanogenesis from CO_2/H_2 in serpentinizing vs. traditional methanogenic settings. Results predict that CO_2 -based methanogenesis will be limited energetic grounds to a subset of the conditions associated with natural serpentinizing systems, with implications for its potential distribution in such systems beyond Earth.

Biosignature potential. The expression of active biology through a signal of enantiomeric excess is shown to transition from clear to likely undetectable values across a range of energy fluxes that span the current uncertain for ocean worlds beyond Earth.