



The Habitat of Early Life: Solar X-ray and UV Radiation at Earth's Surface 4-3.5 Billion Years Ago

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The conditions prevailing on Earth at the time that life formed must have played a crucial role in the processes that led to the origin of life during the Archean. The solar X-ray and UV radiation (0.1-320 nm) received at Earth's surface was an important aspect, and depends on two main variables: the radiation emitted by the young Sun and the absorption by Earth's early atmosphere. The spectrum emitted by the Sun when life formed, between 4 and 3.5 Ga, was modeled here using a solar-like star that has the same age now as the Sun had 4-3.5 Ga. Atmospheric absorption was calculated with the Beer-Lambert law, assuming several density profiles for the atmosphere of the Archean Earth. It was found that almost all radiation with a wavelength shorter than 200 nm is absorbed effectively in all cases, even by very tenuous atmospheres. Longer wavelength radiation is progressively less well absorbed, and its absorption is more sensitive to atmospheric composition. Minor atmospheric components, such as methane, ozone, water vapor, etc., have only negligible effects, but changes in CO₂ concentration can cause large differences in surface flux. In all cases the amount of radiation in the 200-300 nm wavelength range reaching the surface of the Archean Earth is several orders of magnitude larger than what is received at present. This means that any form of life that might have been present at Earth's surface 4-3.5 Ga, must have been exposed to much higher levels of damaging radiation than at present.