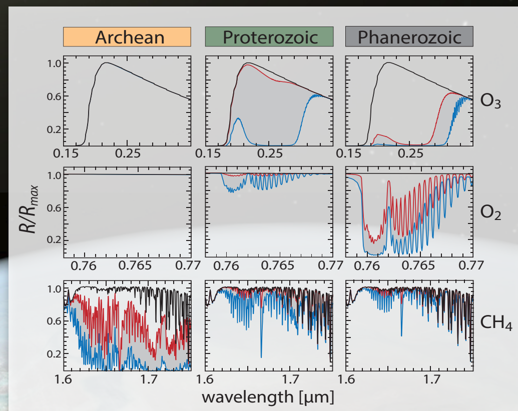
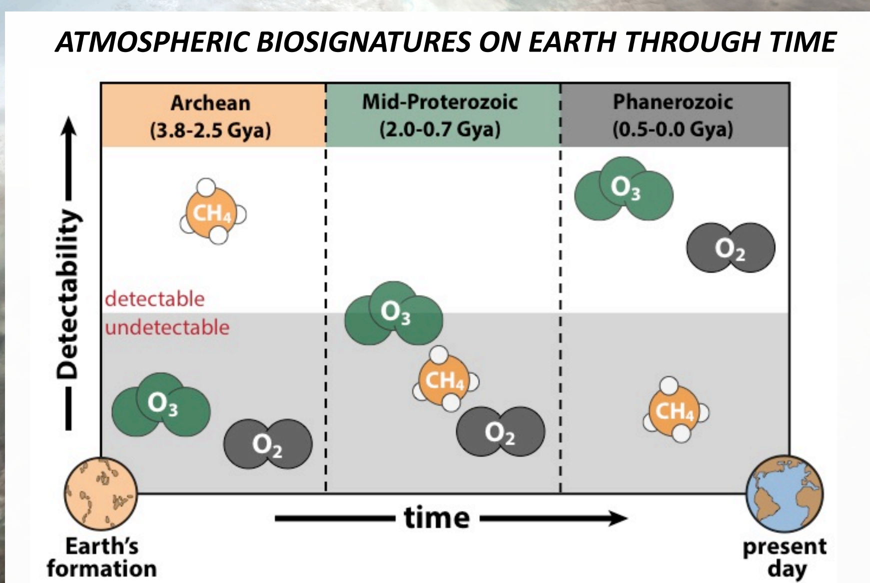
Reinhard C.T., Olson S.L., Schwieterman E.W., and Lyons T.W. *Astrobiology*. April 2017, 17(4): 287-297. doi:10.1089/ast.2016.1598.

False Negatives in Remote Life Detection: Lessons from Early Earth

SYNTHETIC SPECTRA FOR EARTH'S ATMOSPHERE

Reflectance spectra of selected O_2, O_3, and CH_4 bands by geologic eon. Lower abundance limits are red; upper limits are blue. The black line denotes the case with no absorption. CREDIT: FROM REINHARD ET AL., 2017





CREDIT: E. SCHWIETERMAN & C. REINHARD

INNOVATION | Recent advances in geochemical proxies, Earth system models, and spectral analyses by the UCR–led Alternative Earths Team of the NASA Astrobiology Institute provide novel insights into the long-term evolution of the most readily detectable potential biosignature gases: oxygen (O_2), ozone (O_3), and methane (CH_4).

DISCOVERY | Analysis of biosignature gases on early Earth reveals that life detection on ocean-bearing exoplanets, the worlds most likely to harbor a pervasive biosphere, may not be possible via traditional measures. The O_2-CH_4 disequilibrium, often touted as the most convincing biosignature for any Earth-like atmosphere, would have been challenging to detect remotely throughout most of Earth's 4.5-billlion-year history. Moreover, atmospheric O_2/O_3 levels would have been a poor proxy for life for all but the last ~500 million years, despite a thriving biosphere, and atmospheric CH_4 would have been elusive for most of the last ~2.5 billion years.

MISSION RELEVANCE | Remote detection of life on ocean-bearing exoplanets will require telescopes with broad spectral capabilities. Ozone may be the only detectable biosignature on planets like the mid-Proterozoic Earth, for instance, making ultraviolet capability essential. Other promising biosignature gases are strongest in the near-infrared.

BACKGROUND IMAGE | Artist's concept of the planet Kepler-452b, the first near-Earth-size world found in the habitable zone of a Sun-like star. CREDIT: NASA AMES/JPL-CALTECH/T. PYLE