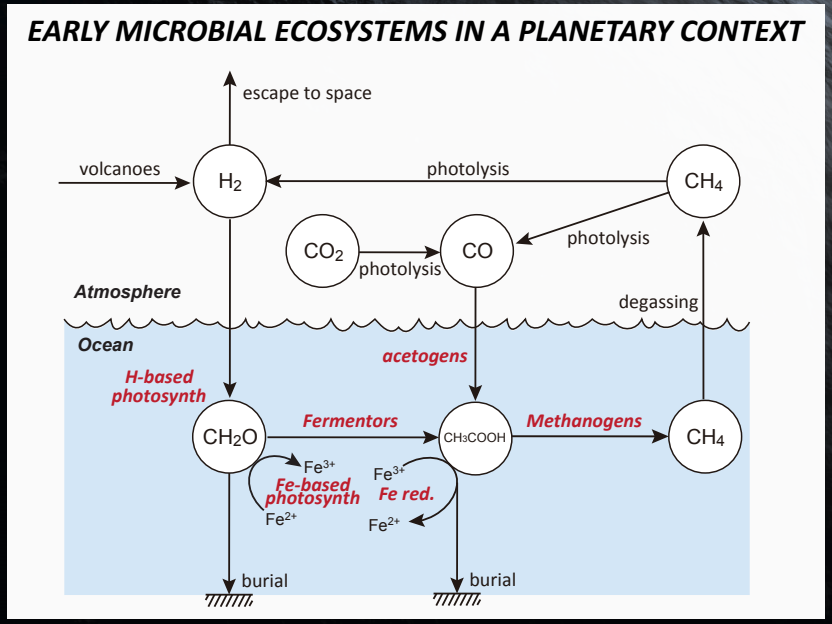
Ozaki et al. | *Nature Geoscience* | December 2017

Cold Stars, Warm Exoplanets and Methane Blankets

Ancient microbes caused Earth's first ever global warming

Innovative model analysis reveals the importance of early photosynthetic life for warming Earth-like planets around dim stars.



CREDIT: K. OZAKI & C. REINHARD

INNOVATION | At the core of the study is a novel numerical model linking microbial ecosystems, volcanism, photochemistry, and atmospheric escape. The unique design of the model allows it to be run millions times in rapid succession, providing compelling statistical analysis of the probability of different climate states.

DISCOVERY | Linking together multiple forms of primitive, non-oxygen-producing photosynthesis leads to a strong amplification of Earth's methane (CH_4) cycle, keeping average surface temperatures warm despite a much dimmer star and providing a solution to the "Faint Young Sun" paradox. These primitive forms of photosynthesis are strongly tied to rates of volcanism and hydrothermal fluid inputs, yielding a radically different planetary physiology from the modern Earth but one that may be common for Earth-like exoplanets.

IMPACT | These results call for a reevaluation of the factors regulating climate and habitability on both the early Earth and other anoxic Earth-like worlds. They also highlight the importance of networked interactions between microbial metabolisms for controlling atmospheric chemistry and climate, and the usefulness of early Earth as a 'natural lab' for Earth-like exoplanets.

MISSION RELEVANCE | These results suggest that observational or theoretical constraints on the rates of geophysical processes, such as volcanic outgassing and hydrothermal circulation, will be critical for the development and application of atmospheric biosignatures on anoxic Earth-like exoplanets.

BACKGROUND IMAGE | *Artist's concept of an ice-covered planet in a distant solar system, resembling what early Earth may have looked like it the right mix of microbial metabolisms and volcanic processes hadn't warmed the climate.* CREDIT: EUROPEAN SOUTHERN OBSERVATORY (EXO) VIA WIKIMEDIA COMMONS