MEASURING N_2 PRESSURE USING CYANOBACTERIA. S. N. Silverman[1,2,3], S. Kopf[1], R. Gordon[4], B. Bebout[3] and S. Som[2,3], [1]Department of Geological Sciences (University of Colorado at Boulder, USA), [2]Blue Marble Space Institute of Science (Seattle, Washington, USA), [3]Exobiology Branch, NASA Ames Research Center (Moffett Field, California, USA), [4]Gulf Specimen Aquarium & Marine Laboratory (USA & Wayne State University, USA)

Introduction: Assessment of whether extrasolar planets are deemed habitable or inhabited will be based on their atmospheric composition. Added insight regarding habitability will be obtained by comparing these exo-atmospheres to that of habitable Earth. Earth's atmosphere has remained habitable despite varying in redox state and total mass over geological time. As such, "snapshots" of Earth's atmosphere through the planet's evolution can provide a catalogue of different habitable atmospheres. At any timepoint in Earth's history, an upper limit can be placed on the number of possible air constituents by knowledge of atmospheric pressure at that time. Experimentally, this can be broken down by focusing on trends of specific gases over history.

Dinitrogen (N_2) is thought to have been a major, though not necessarily constant, constituent of Earth's atmosphere throughout the planet's history. Despite its physical importance as a key component of the atmosphere and its role as the largest reservoir of nitrogen at the Earth's surface, only a few constraints exist for the partial pressure of N_2 [1], [2], [3], [4]. In this study we evaluate two new potential proxies for atmospheric N_2: the physical spacing between heterocysts and the isotopic signature of nitrogen fixation in filamentous cyanobacteria.

Experimental background: Heterocyst-forming filamentous cyanobacteria are some of the oldest photosynthetic microorganisms on Earth, and debated fossilized specimens have been found in sedimentary rocks as old as 2 Ga [5]. These organisms overcome nitrogen limitation in their aqueous environment through cellular differentiation along their filaments. The specialized cells that develop, known as heterocysts, fix the nitrogen and laterally distribute it to neighboring cells along the filaments.

Because the concentration of the dissolved N_2 available to the filaments correlates directly with the atmospheric partial pressure (Henry's law constant for N_2 gas in water is 6.1 x 10^{-4} mol L^{-1} atm^{-1} [6]), any preservable physiological response of the organism to the changed N_2 availability constitutes a potential proxy for atmospheric N_2.

Experimental approach: In the laboratory, we have examined how pN_2 is reflected in the heterocyst spacing pattern and in the isotopic signature of nitrogen fixation by subjecting the representative species *Anabaena cylindrica* and *Anabaena variabilis* to different N_2 partial pressures during growth at constant temperature and lighting (in media free of combined nitrogen).

Results: We show experimentally that the distance between heterocysts and the nitrogen isotope fractionation measured in bulk biomass reflect the nitrogen partial pressure experienced by *Anabaena cylindrica* organisms. As such, this renders them an ideal target to potentially record atmospheric nitrogen concentrations on ancient Earth. Current work is investigating these responses in *Anabaena variabilis*. When heterocystous cyanobacteria fossilize, these morphological and isotopic signatures should preserve information about the atmospheric N_2 partial pressure at that time. Application of this relationship to the rock record may provide a paleoproxy to complement the two existing geobarometers [1], [2].

References: [1] Som S. M. et al. (2016) *Nat. Geosci., 9,* 448–451. [2] Som S. M. et al. (2012) *Nature, 484*, 359–362. [3] Marty B. et al. (2013) *Science, 342,* 101–104. [4] Berner R. A. (2006) *Geochim. Cosmochim. AC, 65,* 685–694. [5] Licari G. R. and Cloud P. E. (1968) *PNAS*, *59*, 1053–1060. [6] Sander R. (2015) *Atmos. Chem. Phys., 15,* 4399–4981.