There was probably more nitrogen in the Archean atmosphere – This would have helped resolve the Faint Young Sun paradox

COLIN GOLDBLATT[1]*, ADRIAN J. MATTHEWS[2], MARK CLAIRE[3], TIMOTHY M. LENTON[2], ANDREW J. WATSON[2] AND KEVIN J. ZAHNLE[1]

[1]NASA Ames Research Center, Space Science and Astrobiology Division, MS 245-3, Moffett Field, CA 94035, USA (*correspondence: colin.goldblatt@nasa.gov)
[2]School of Environmental Sciences, University of East Anglia, Norwich, NR4 7TJ, UK
[3]Virtual Planetary Laboratory & Astrobiology Program, University of Washington, Seattle, WA 98195, USA

The early Earth received less energy from the Sun than today but was not permanently glaciated, an apparent contradiction known as the Faint Young Sun paradox. A stronger greenhouse effect is required, but constraints on greenhouse gas abundance leave this paradox unresolved. Here we show that doubling the atmospheric nitrogen inventory would solve the Faint Young Sun paradox. Whilst nitrogen is nearly radiatively inert, increased atmospheric pressure broadens the absorption lines of radiatively active gases. Higher pressure also steepens the lapse rate, further warming the surface. With 10^{-2} bar CO2 at 2.5 Ga, doubling the present atmospheric nitrogen (PAN) would have given 4.5°C extra warming, yielding a surface temperature of 12°C.

Venus' atmosphere has over three times the nitrogen of Earth's atmosphere, suggesting high atmospheric nitrogen was possible for early Earth. Nitrogen is sequestered in the solid Earth, with 0.5 PAN in the continental crust and at least 1 PAN in the mantle. The crustal reservoir necessarily grew with the continents. Nobel gas systematics indicate that mantle nitrogen is not primordial, but from subducted ammonium. These reservoirs accumulated since the late Archean, consistent with atmospheric nitrogen being twice the present level during the Archean.

A higher nitrogen inventory would have slowed the diffusion limited rate of hydrogen escape on the early Earth, thus delaying planetary oxidation. High atmospheric nitrogen inventories might be applicable to other planets, both in our solar system (the Noachian on Mars) and beyond.

Watching rocks grow: Self-organization of depositional patterns at geothermal hot springs

NIGEL GOLDENFELD

Department of Physics and Institute for Genomic Biology, University of Illinois at Urbana-Champaign, 1110 West Green Street, Urbana, IL 61801, USA (nigel@uiuc.edu)

Nature abounds with beautiful and striking landscapes, but a comprehensive understanding of their forms requires examples where detailed comparisons can be made between theory and experiment. Geothermal hot springs produce some of the most rapidly changing terrestrial landscapes, with reported travertine (calcium carbonate) growth rates as high as 5mm per day. Unlike most landscapes, the patterns of which are the result of erosion processes on timescales of millions of years, the hot-spring depositional landscapes exhibit a spectacular cascade of nested ponds and terraces, for which the origins and quantitative characterization have remained elusive. In this talk [1], we take advantage of this millionfold difference in geological timescale to present a novel combination of data from time-lapse photography, computer simulation and mathematical modelling that explains the emergence of the large-scale pond and terrace patterns, predicts and verifies the dynamics of their growth and shows that these patterns are scale invariant.

[1] Veysey & Goldenfeld (2008) *Nature Physics* **4**, 310-313