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Solid Earth
Discussions

Interactive comment on "The regulation of the air: a hypothesis" *by* E. G. Nisbet et al.

E. G. Nisbet et al.

e.nisbet@es.rhul.ac.uk

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Does the rubisco tail wag the geochemical dog? We would argue first that rubisco is not the tail but the heart and lungs of the dog, and secondly that tail, heart, lungs and whole dog all wag together. There is of course a clear factual basis for the long term linkage between carbonate precipitation and silicate weathering. We fully agree with this, and with the very extensive literature on the matter. Moreover, carbonate precipitation would obviously occur on an abiotic planet – even on Venus the atmosphere is close to the equilibrium of the calcite + quartz âĂą wollastonite + CO2 reaction, which should lead to carbonate formation. However, we point to two observations. The first is that history is the sum of the days. The sum of what happens in each moment adds up to the long-term record of the aeon. Almost all the CO2 in the air is a biological product, excepting a proportionately tiny volcanic flux. The gross annual biological fluxes are very large, and if rubisco's CO2:O2 specificity was significantly higher, biology would

deplete the air in a few years. In much of the northern hemisphere in the modern CO2 cycle, the annual spring drawdown is presently very roughly 3% of the carbon in the air. If specificity were higher, it would only take a few decades or so to deplete the total atmospheric burden. Very small changes in the photosynthesis/respiration balance can change the atmospheric reservoir in a geological instant. This contrasts with the slowness of the silicate weathering response, which takes hundreds of thousands of years to act. "The present is the key to the past". Given that each present day the CO2 of the air is managed by biology, Lyell's logic would imply that this was true in the past also.

That leads to the question: 'who sets the stage?'. What controls the precipitation of carbon, both in the sediment as organic matter and also in sedimentary carbonate. The key control is the mixing ratio atmospheric CO2 Precipitation of organic matter depends on organic carbon capture, controlled by the specificity of rubisco. The deposition of sedimentary carbonate and also the weathering of silicate depend on the pH of sea- and rain-water, which is in turn dependent on atmospheric CO2. If rubisco specificity sets atmospheric CO2, then rubisco must also set the broad geochemical stage. Once the stage is set, the long-term controls can operate. The reason that the controls on carbonate deposition on Earth are different from the controls on Venus is

While supporting the hypothesis of a clement Archean ocean, we fully agree that the temperature of the Archean ocean is a matter of much dispute and there is much evidence in support of the 'hot ocean' argument. We fully accept that our statement "That for any planet, chance trajectories of surface temperature which sustain clement conditions over geological aeons are very improbable" is a matter of hypothesis and conjecture: we agree that Prof. Schwartzman's view "rather quite probable" is an equally valid hypothesis. This is after all a hypothesis paper.

However, the more general point we propose, as made in our Figure 3, is that life, through the action of natural selection on rubisco's specificity, has found an evolutionary stable strategy for the planetary atmosphere. By management of the CO2 content of the air, we therefore suggest that the natural selection of rubisco specificity, as it controls and co-evolves with abiotic geochemistry, has allowed biology to maintain optimal conditions on the earth's surface.

Interactive comment on Solid Earth Discuss., 3, 769, 2011.