View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by Copenhagen University Research Information System

UNIVERSITY OF COPENHAGEN

Geochemical and biologic constraints on the Archaean atmosphere and climate – A possible solution to the faint early Sun paradox

Rosing, Minik Thorleif; Brid, Dennis K.; Sleep, Norman H.; Bjerrum, Christian J.

Publication date:
2010

Document version
Publisher's PDF, also known as Version of record

Document license:
CC BY

Citation for published version (APA):
Rosing, M. T., Brid, D. K., Sleep, N. H., & Bjerrum, C. J. (2010). *Geochemical and biologic constraints on the Archaean atmosphere and climate – A possible solution to the faint early Sun paradox*. Abstract from EGU General Assembly 2010, Vienna, Austria.

Download date: 07. Apr. 2020

Geophysical Research Abstracts
Vol. 12, EGU2010-15268, 2010
EGU General Assembly 2010
© Author(s) 2010

Geochemical and biologic constraints on the Archaean atmosphere and climate – A possible solution to the faint early Sun paradox.

Minik T. Rosing (1), Dennis K. Bird (2), Norman H. Sleep (3), and Christian J Bjerrum (1)

(1) Nordic Center for Earth Evolution, University of Copenhagen. Øster Voldgade 5-7, DK-1350, København K., Denmark., (2) Dept. of Geological and Environmental Sciences, Stanford University, Stanford, Ca. 94305, USA, (3) Dept. of Geophysics, Stanford University, Stanford, Ca. 94305, USA

There is ample geological evidence that Earth's climate resembled the present during the Archaean, despite a much lower solar luminosity. This was cast as a paradox by Sagan and Mullen in 1972. Several solutions to the paradox have been suggested, mostly focusing on adjustments of the radiative properties of Earth's atmosphere e.g. Kasting (1993), by increasing the mixing ratio of CO2 and/or adding various other greenhouse gasses. We have used banded iron formation (BIF), which are chemical sediments precipitated out of the Archaean ocean to characterize the composition of the atmosphere. The stability relations of magnetite, which is ubiquitous in Archaean BIFs, preclude CO2 mixing ratios much higher than the present atmospheric level. Likewise, magnetite stability is consistent with atmospheric H2 controlled at the lower limit for H2 metabolism by methanogenic phototrophic organisms.

In the absence of substantial compensation for the lower solar irradiance by greenhouse gasses in the atmosphere, we have examined the factors that controlled Earth's albedo. These are primarily the surface albedo of Earth and the abundance and properties of clouds. We have applied a model that takes into account the apparent growth of Earth continents (Collerson and Kamber 1999) and the absence of land vegetation during the Precambrian for the evolution of the surface albedo, and a model for the abundance and properties of clouds that takes into account the lower abundance of biogenic cloud condensation nuclei in a less productive prokaryotic world. The higher transparency of the atmosphere for short wave incoming solar radiation and the lower surface albedo on an early Earth dominated by oceans, provided sufficient compensation for the lower solar irradiance to allow the presence of liquid oceans, even at greenhouse gas concentrations broadly similar to the present day values.

We therefore suggest that the thermostasis during Earth geologic record, is not paradoxical, but is the combined effect of many factors, which are to a large part biologically controlled.

References

Collerson, K. D. and B. S. Kamber (1999). "Evolution of the continents and the atmosphere inferred from Th-U-Nb systematics of the depleted mantle." Science 283(5407): 1519-1522.

Kasting, J. F. (1993). "Earths Early Atmosphere." Science 259(5097): 920-926.

Sagan, C. and G. Mullen (1972). "Earth and Mars - Evolution of Atmospheres and Surface Temperatures." Science 177(4043): 52-&.