Ocean Anoxia: The end-Permian Mass Extinction

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Ocean Deoxygenation: Past, Present, and Future

PAGES 409–410

oxygen concentrations highlights progress

periods (385–360 million years ago), widespread anoxia in shallow continental seas coincided with an extended biotic crisis. Anoxia was also widespread in both shallow marine and deep ocean environments during the Permian-Triassic extinction (~252 million years ago), marked by the loss of

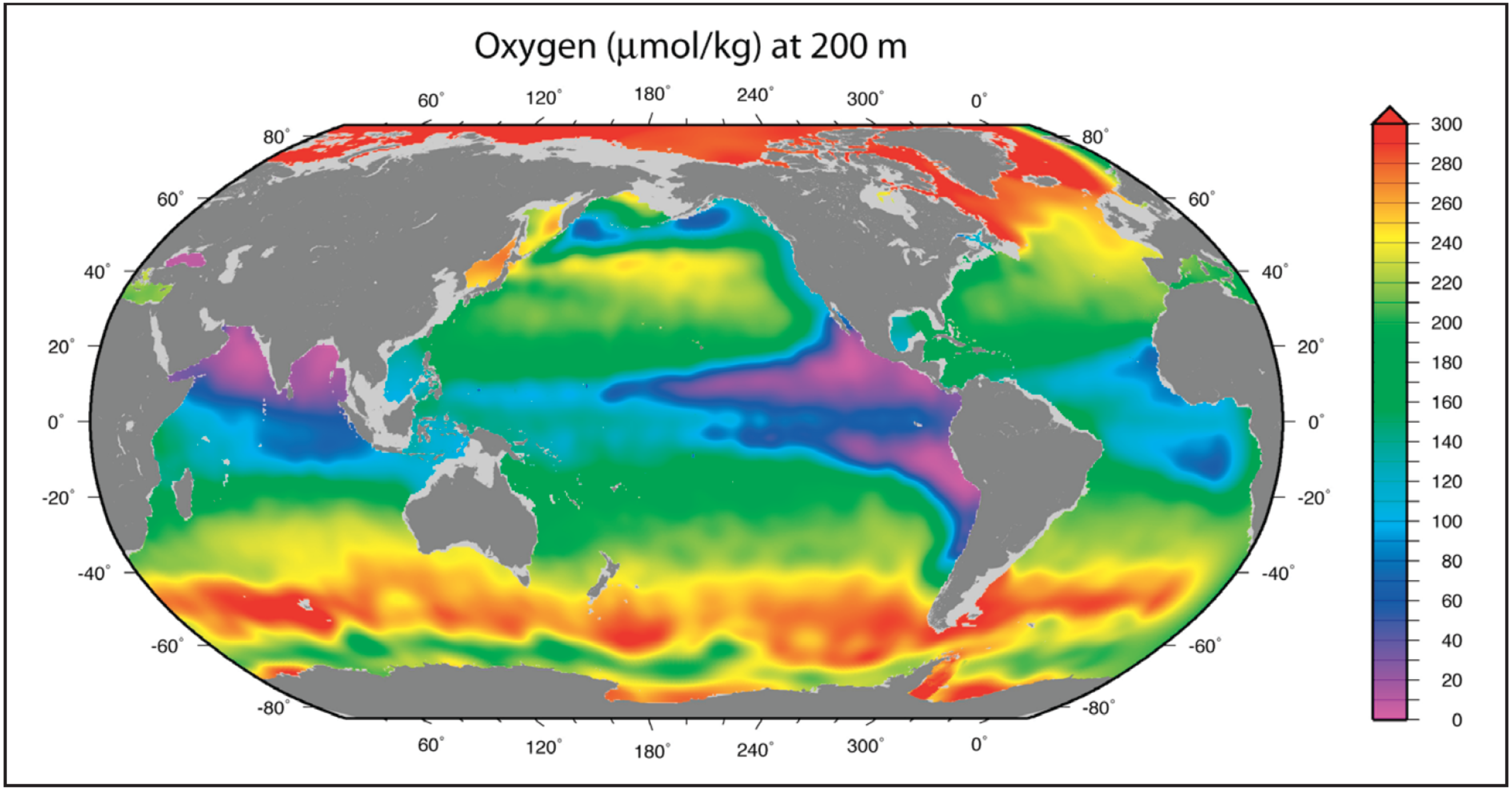


*Fig. 1. Mean global ocean oxygen concentrations at 200 meters below the surface. Note the extensive regions of low oxygen (oxygen minimum zones) throughout the low-latitude oceans and the subarctic Pacific. Data from the World Ocean Circulation Experiment Global Hydrographic Climatology [*Gouretski and Koltermann, *2004].*

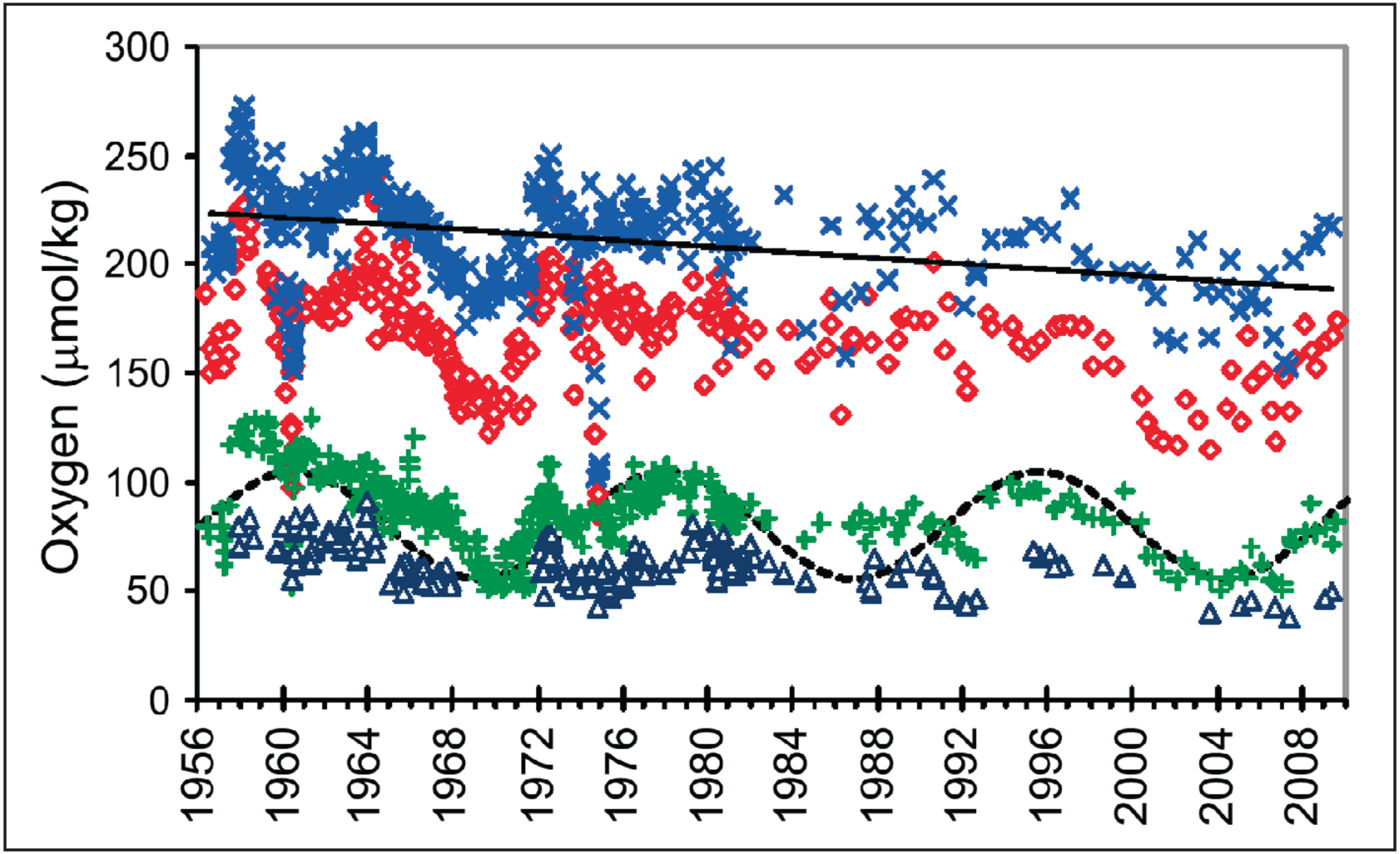
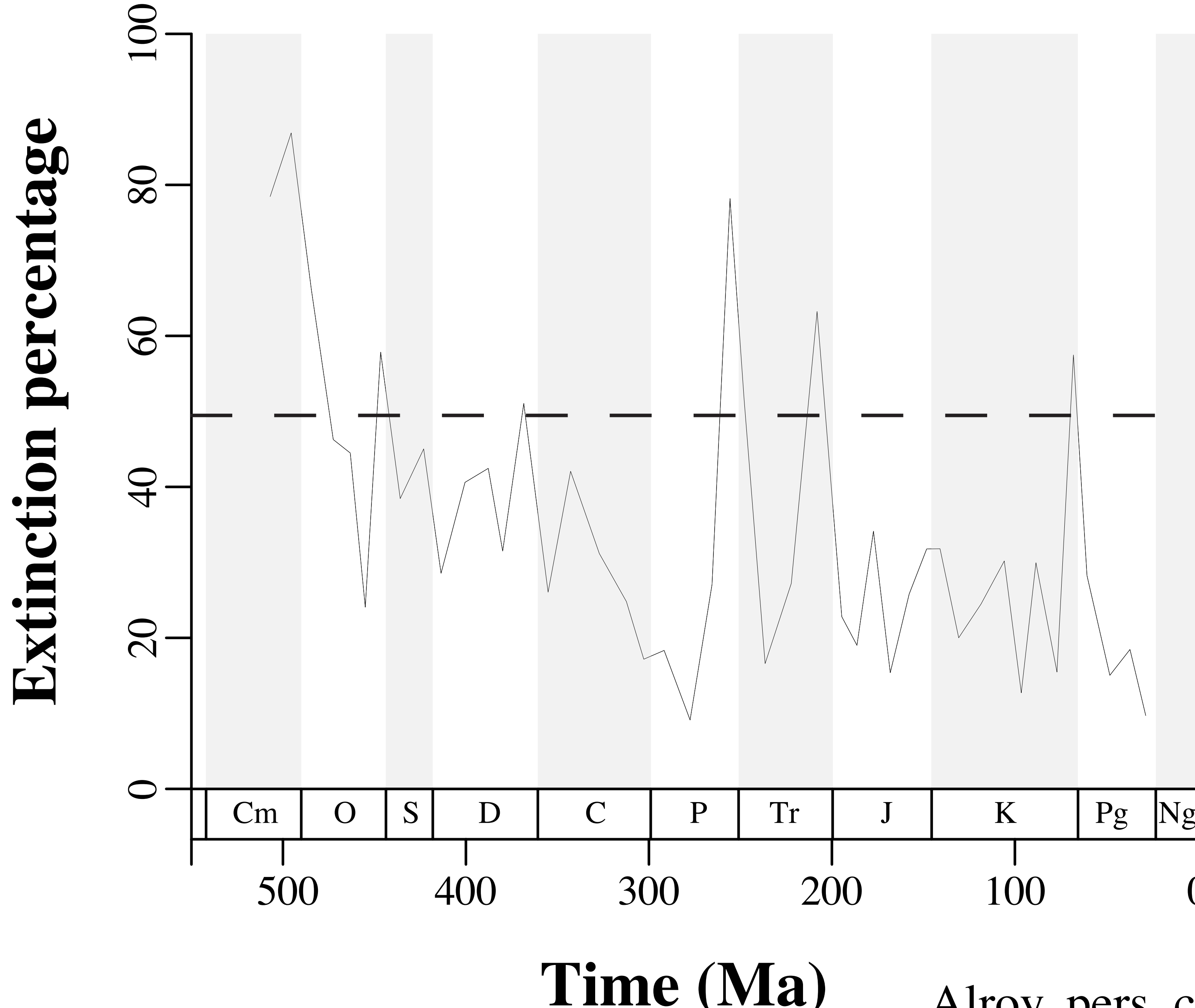
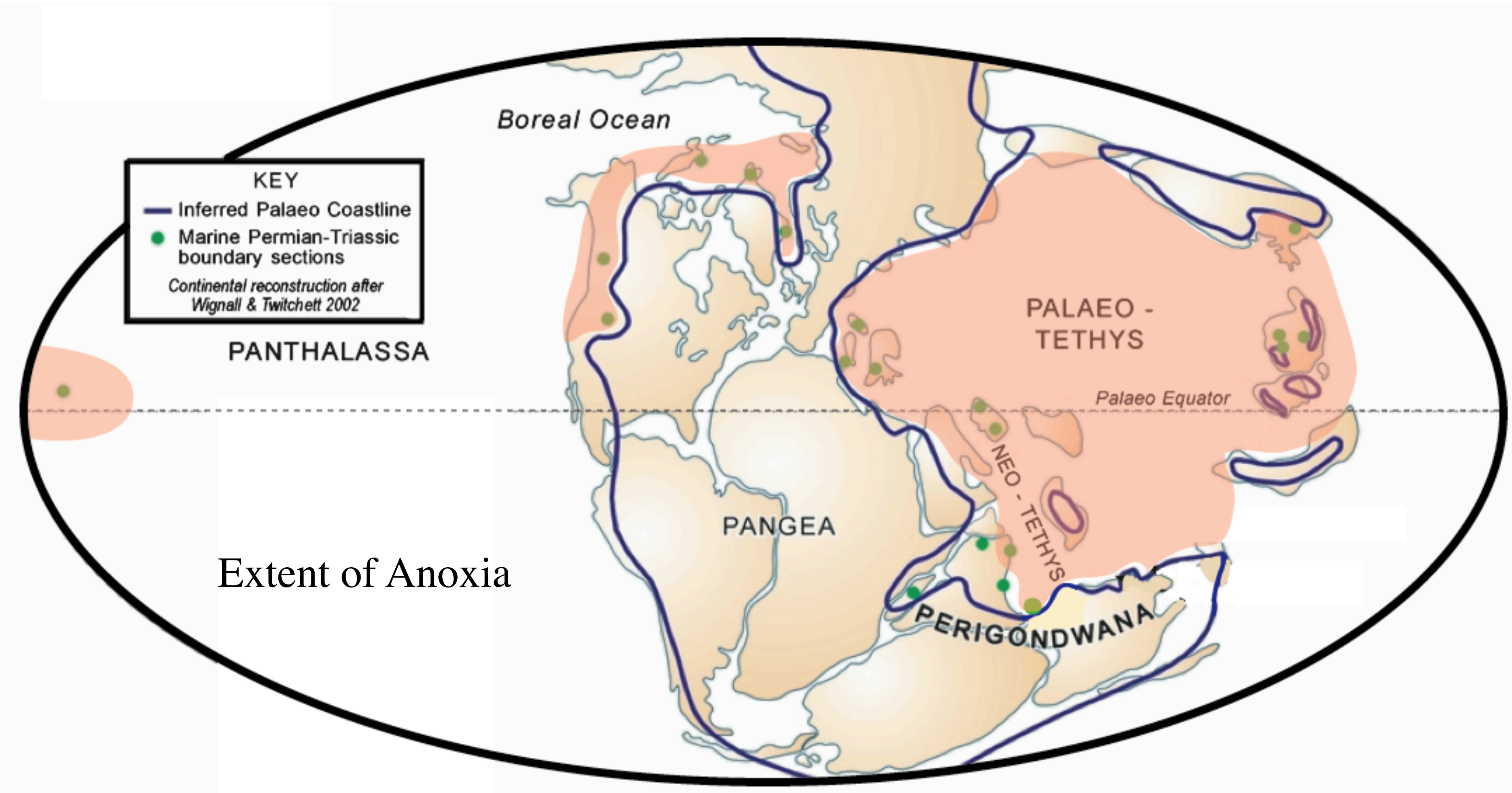


*Fig. 2. The decadal trend and oscillations in oxygen concentrations on constant potential density surfaces (isopycnals). Data are shown for isopycnals 26.5 (blue crosses), 26.7 (red diamonds), 26.9 (green pluses), and 27.0 (dark blue triangles) at Ocean Station P (50°N, 145°W). Solid line is the linear regression of the 26.5 isopycnal showing an annual oxygen loss rate of 0.67 micromole per kilogram. The dashed sine wave shows that the oscillation on the 26.9 isopycnal has an amplitude of 50 micromoles per kilogram (centered on 80 micromoles per kilogram) and a period of 18.6 years [*Whitney et al.*, 2007; F. Whitney, personal communication, 2011].*



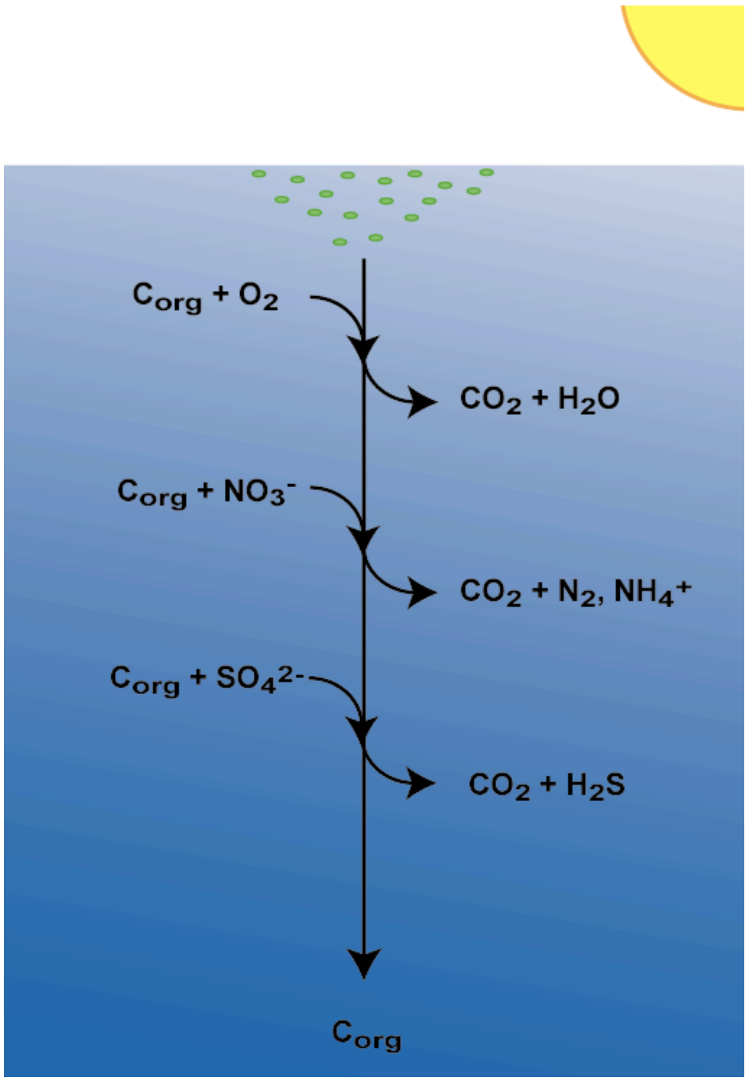
Alroy, pers. comm.

Permian-Triassic Earth

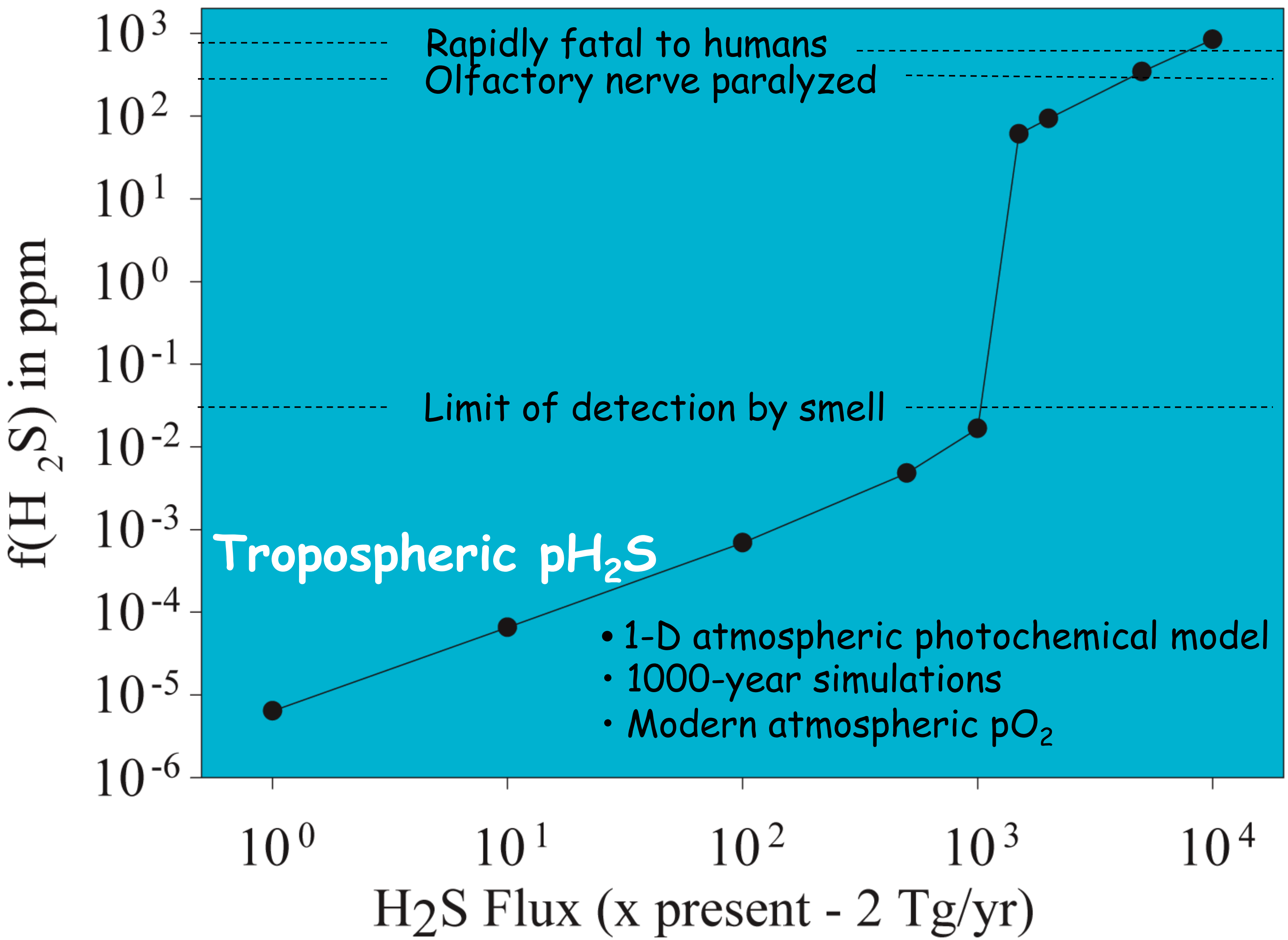


Modified after (Thomas et al., 2004)

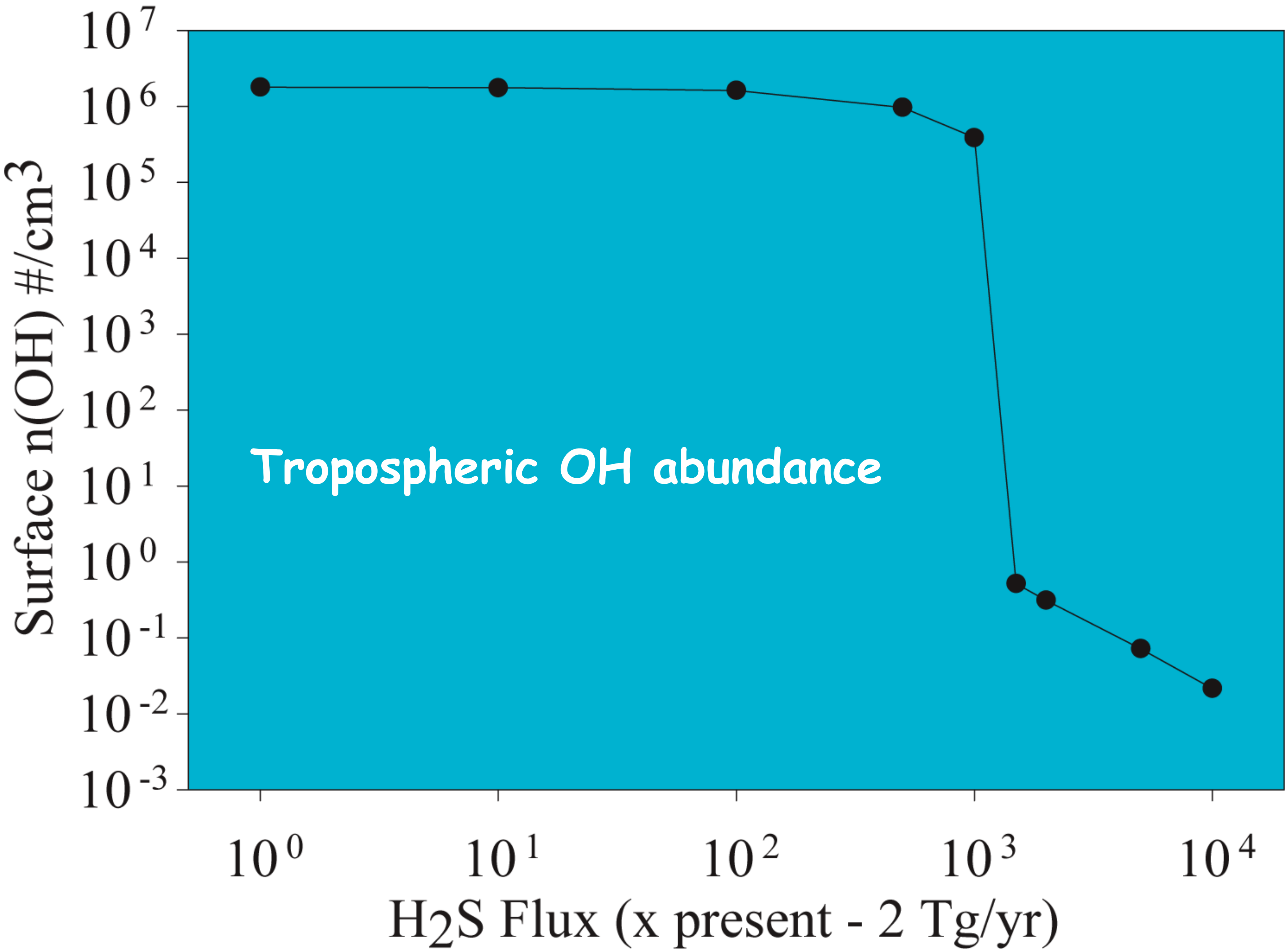
Photic-Zone Euxinia



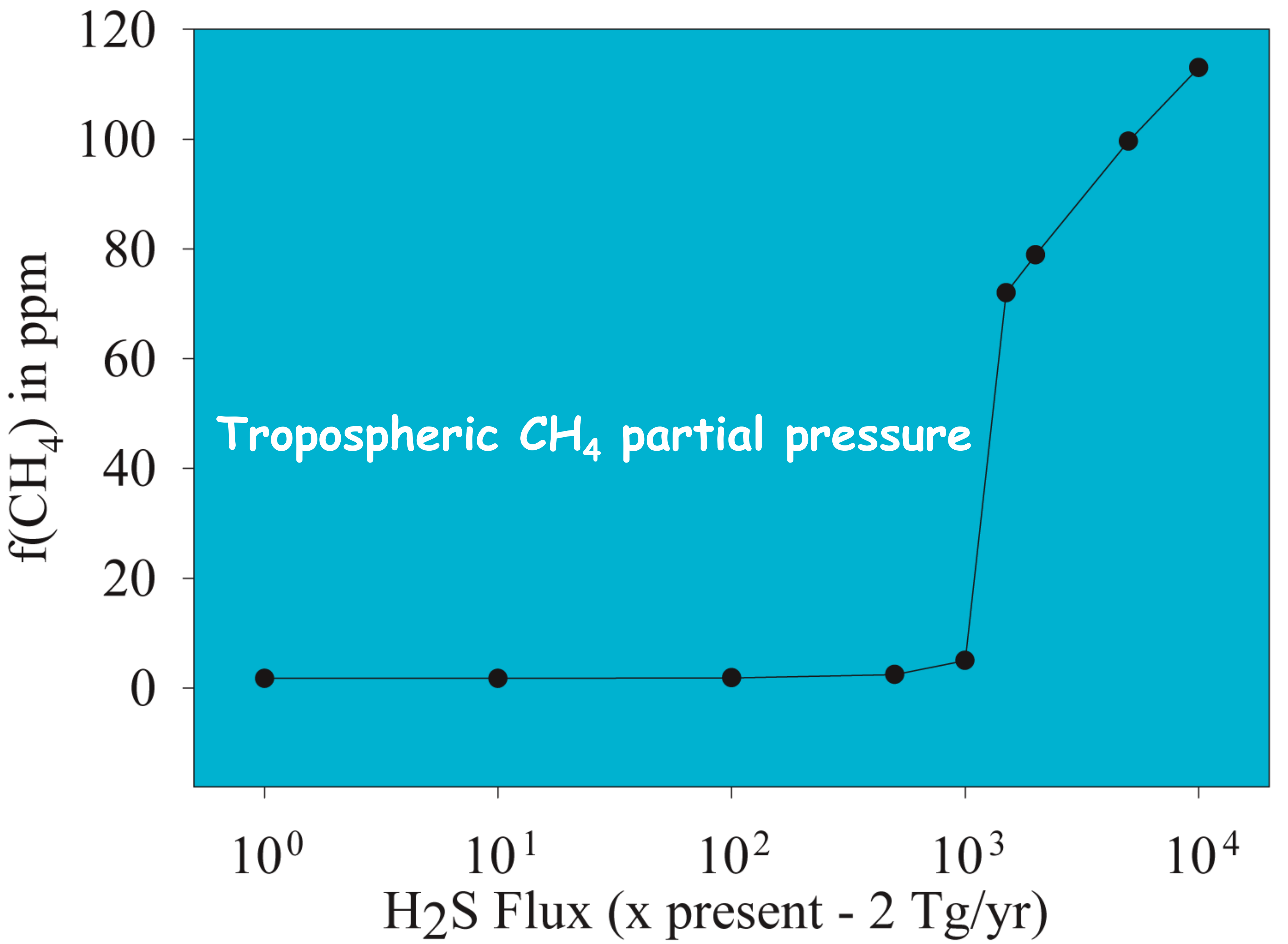
- Anoxic and sulfidic conditions



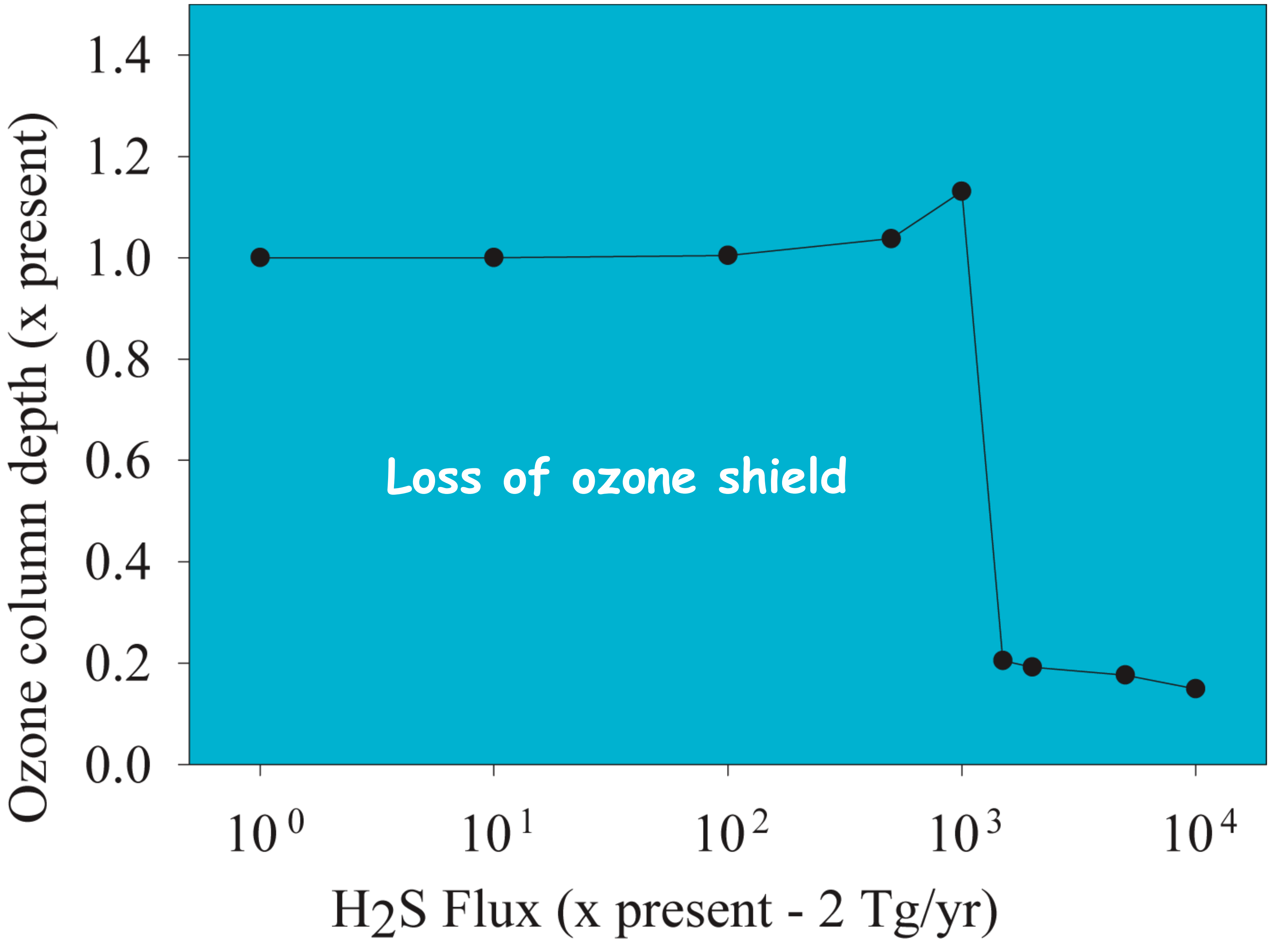
Kump, Pavlov and Arthur (2005)



Tropospheric OH abundance
Surface n(OH) #/cm3
H2S Flux (x present - 2 Tg/yr)
10 7
10 6
10 5
10 4
10 3
10 2
10 1
10 0
10 -1
10 -2
10 -3
10 0
10 1
10 2
10 3
10 4



120
100
80
60
40
20
0
f(CH_4) in ppm
Tropospheric CH_4 partial pressure
10^0
10^1
10^2
10^3
10^4
H_2S Flux (x present - 2 Tg/yr)



Ozone column depth (x present)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Loss of ozone shield
10^0
10^1
10^2
10^3
10^4
H_2S Flux (x present - 2 Tg/yr)

Rotten Sulfur Brew, The Great Dying?

www.astrobio.net/cgi-bin/h2ps.cgi?sid=672&ext=.ps

A Welsh View: OK, Who Farted?
... "The end-Permian is puzzling," Professor Lee Kump of Penn State University told the Geological Society of America, meeting in Seattle. ...
xo.typepad.com/blog/2003/11/ok_who_farted.html - 20k - Cached - Similar pages

Ananova - Stink bomb gas 'may have caused mass **extinction'...** may have taken place to the **smell** of rotten eggs **...** Theories for the end-Permian **extinction** include massive volcanic **...** But Dr Lee R **Kump**, professor of geosciences at **...** www.ananova.com/news/story/sm_835148.html - 13k

- Cached - Similar/\pages

Economist.com

The only problem with Dr Kump's hypothesis is that he has no actual evidence for it. But he hopes to gather some soon, from rocks in Japan. And if he does, you can bet that yet another theory will come oozing down the catwalk to sneer at it.

Evidence for sulÆdic deep water during the Late Permian in the East Greenland Basin

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Yanan Shen Centre de Recherche en Geo
Succursale Centre-Ville, Montr

ABSTRACT

A detailed study of the size distribution of fra Upper Permian Ravnefjeld Formation was perf Late Permian ocean. In contrast to framboidal p er and less variable size distribution of pyrite f Ravnefjeld Formation provides persuasive evid conditions in the East Greenland Basin. However populations show a similar distribution. The wi to 2 28.2Ω)in the black shales of the Ravnefjeld (up to 52.7Ω)relative to seawater sulfate, and m cycling in sulÆdicwater columns as well as withi Greenland Basin indicate that environmental str could have caused the biotic crisis in the Late P

Keywords: pyrite, framboids, sulÆdic,stable sulfu

INTRODUCTION

It is well known that the greatest mass extinction over the history of life occurred at the Permian-Triassic (P-Tr) boundary, when . 50% of all invertebrate families and perhaps 90% or more of existing species perished in the oceans (e.g., Erwin, 1994). Numerous models have been proposed to explain the

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23. Two caveats must be considered in interpreting any spatially resolved STS measurements. The DOS is convolved with the finite size of the tip leading to a spatial broadening. Also, a constant-current set point determines the tip-sample separation for each measurement, leading to an exponential increase in the differential conductivity when the tip-sample separation decreases, such as off the ends of the chains.
24. Choices with positive t_1 are ruled out from modeling longer chains.

Photic Zone Euxinia During the Permian-Triassic Superanoxic Event

Kliti Grice,[1*] Changqun Cao,[2] Gordon D. Love,[3]
Michael E. Böttcher,[4] Richard J. Twitchett,[5]
Emmanuelle Grosjean,[3] Roger E. Summons,[3]
Steven C. Turgeon,[6] William Dunning,[1] Yugan Jin[2]

Carbon and sulfur isotopic data, together with biomarker and iron speciation analyses of the Hovea-3 core that was drilled in the Perth Basin, Western Australia, indicate that euxinic conditions prevailed in the paleowater column during the Permian-Triassic superanoxic event. Biomarkers diagnostic for

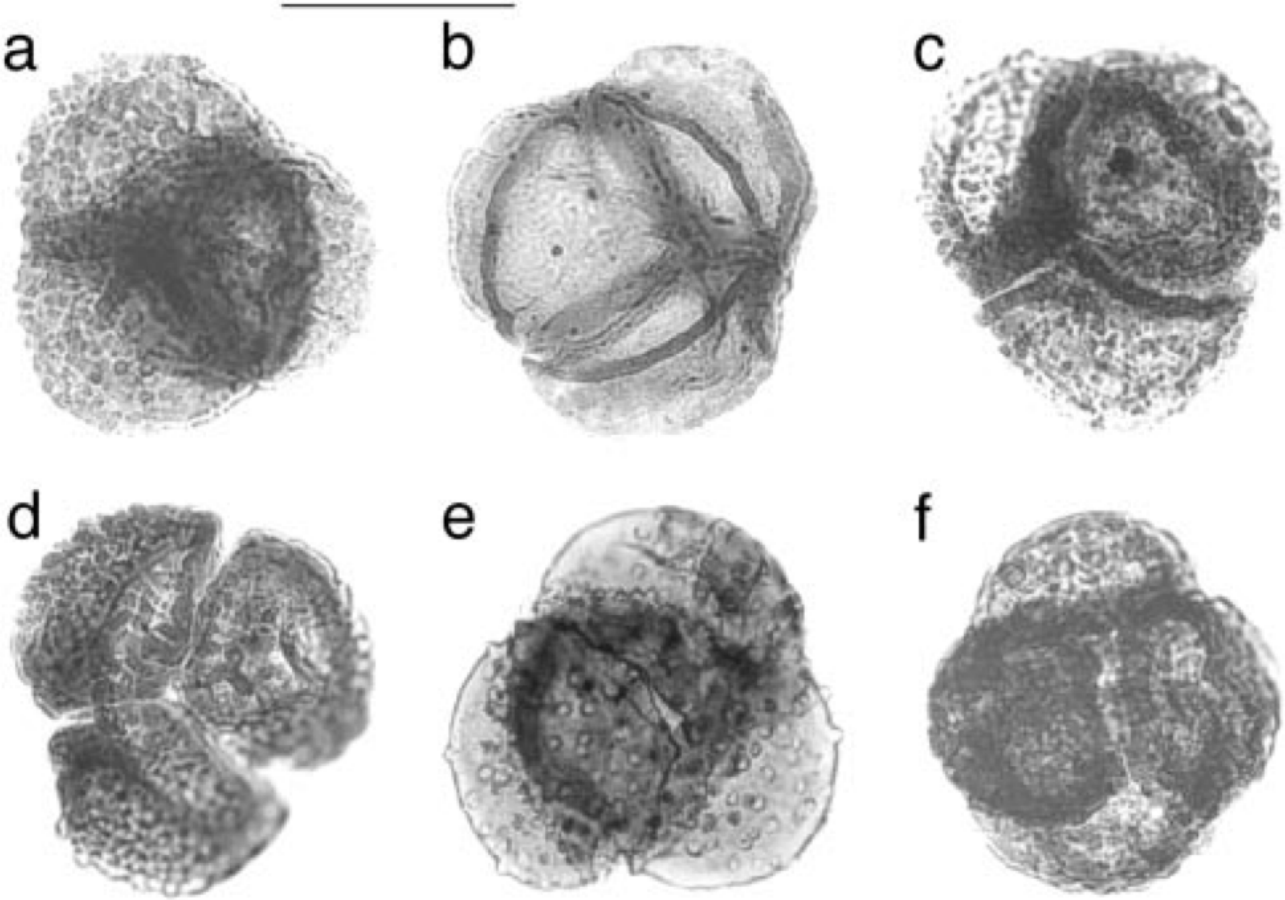

Fig. 1. Selection of the latest Permian microspores of heterosporous lycopsids in tetrads from the Wordie Creek Formation, southern Jamesonland, East Greenland. Specimens can be assigned to various species of microspore form-genera *Lundbladispora* (*a*, *c*, *e*, and *f*), *Densoisporites* (*b*), and *Uvaesporites* (*d*). (Scale bar = 50 μm.)

Environmental mutagenesis during the end-Permian ecological crisis

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Johanna H. A. van Konijnenburg-van Cittert*¶, Wolfram M. Kürschner*, and Mark A. Sephton‖

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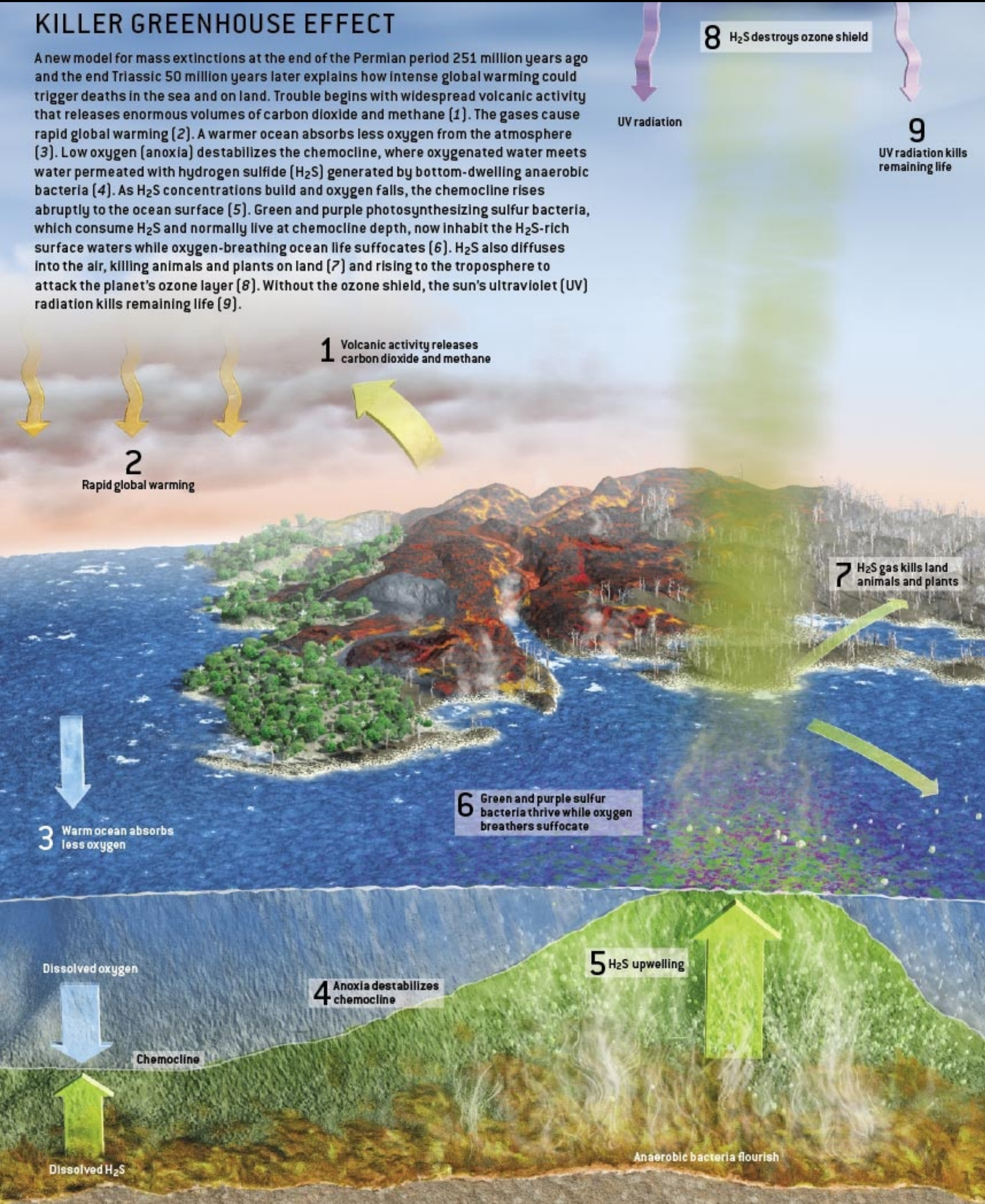
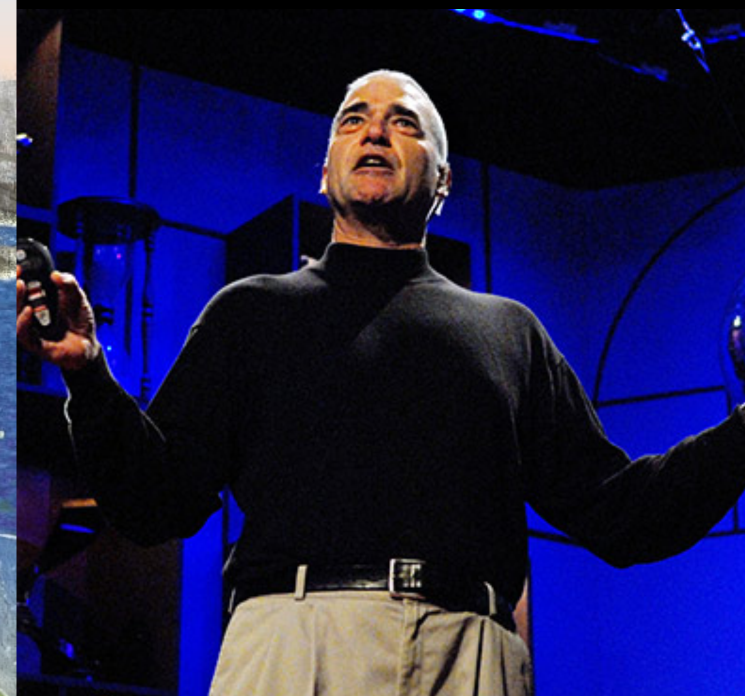
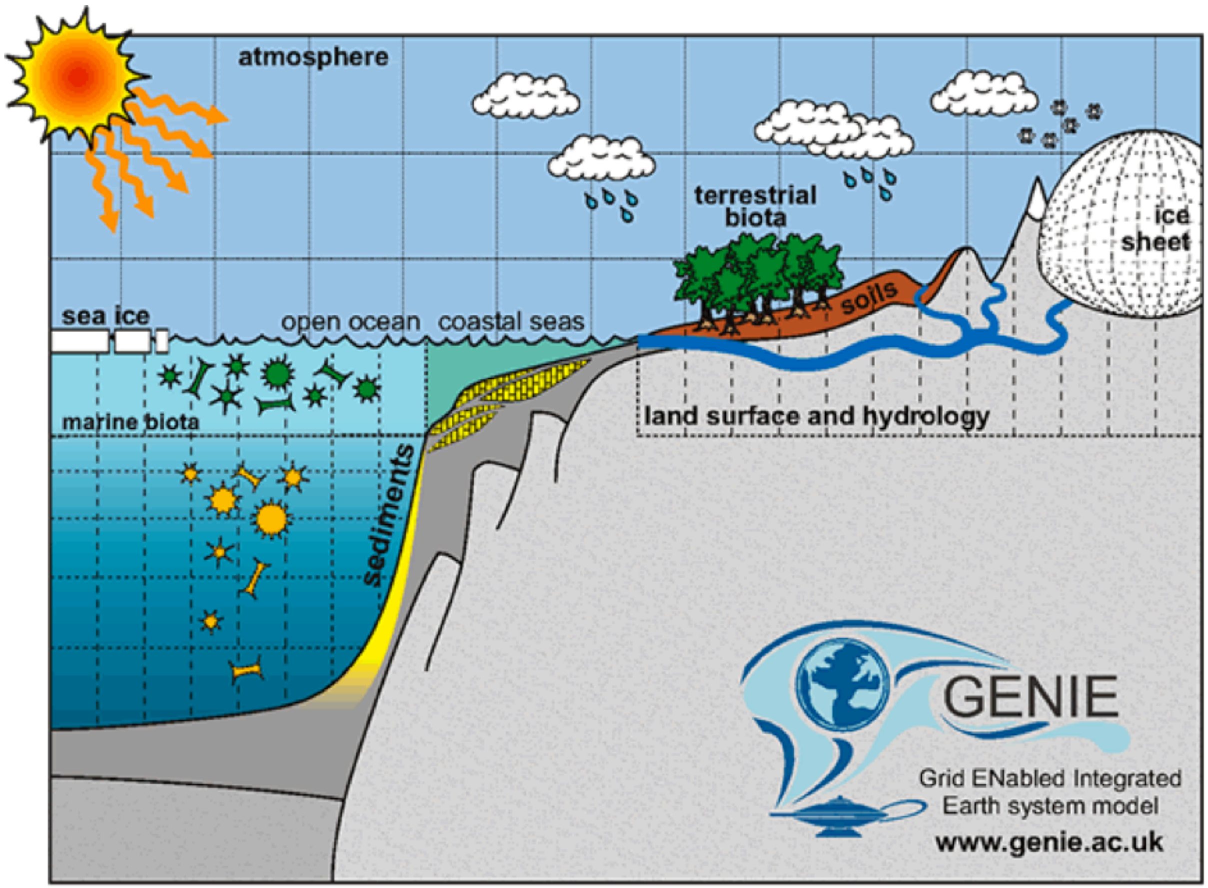




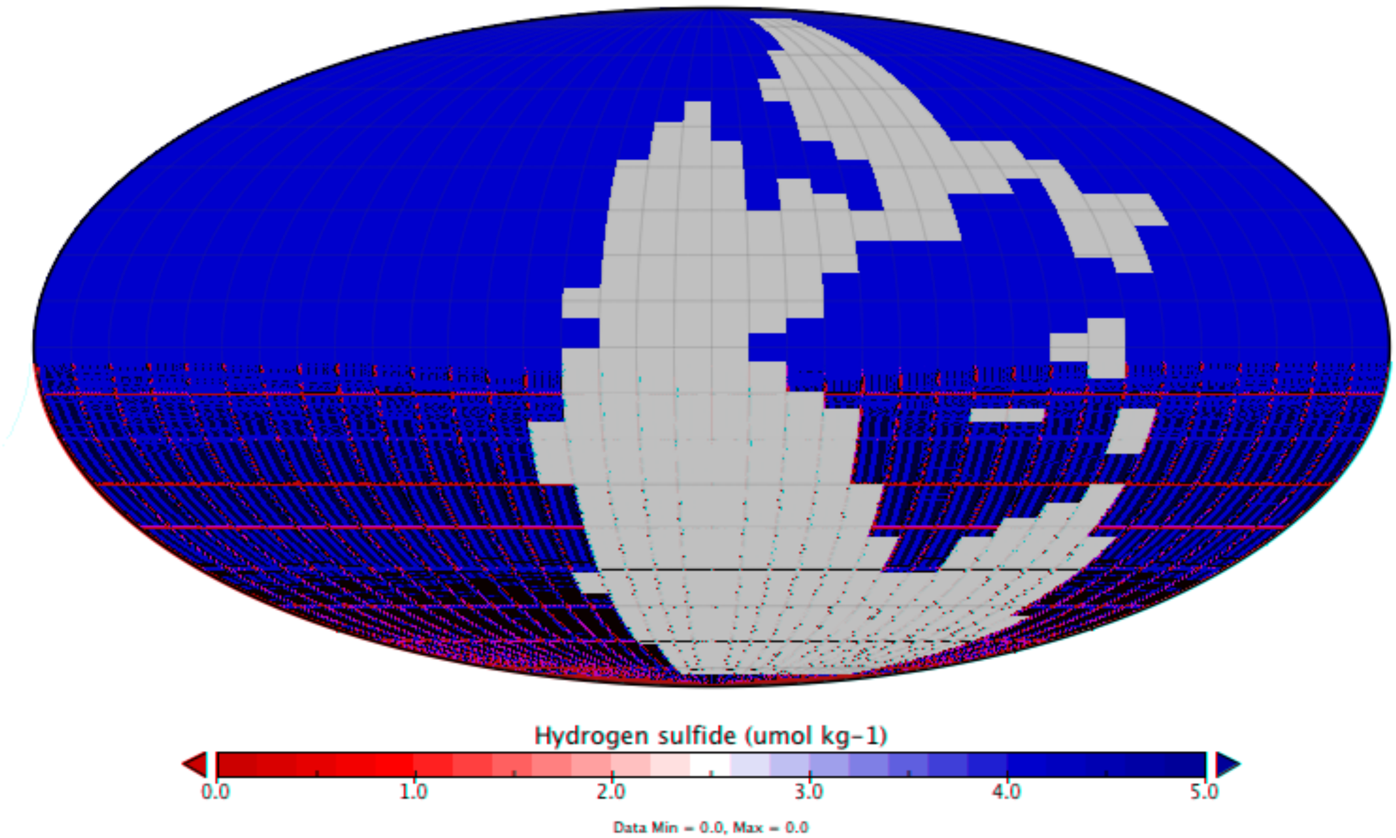
P. Ward (Sci Am. 2006)

Method

- Spatially-resolved Earth system models

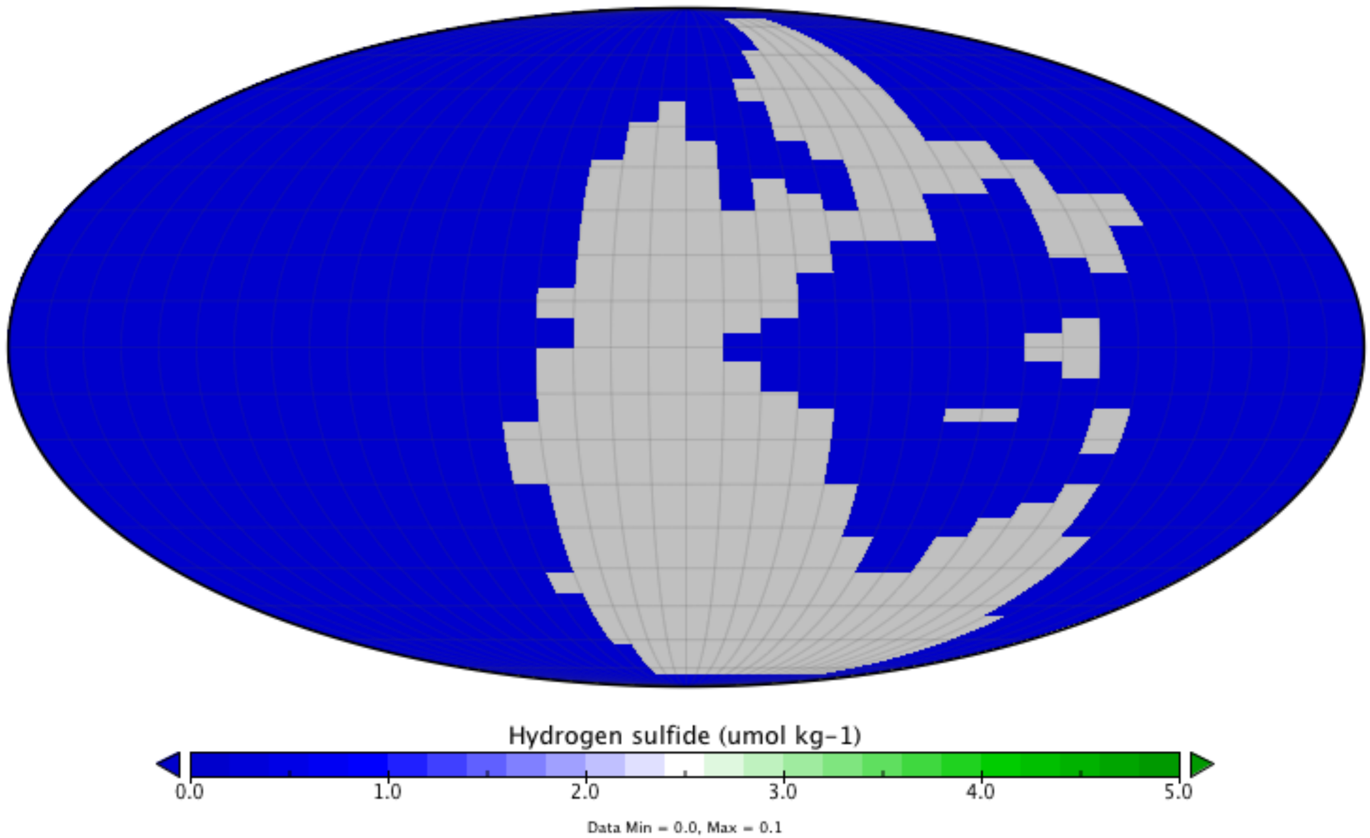


Surface Ocean H_2S



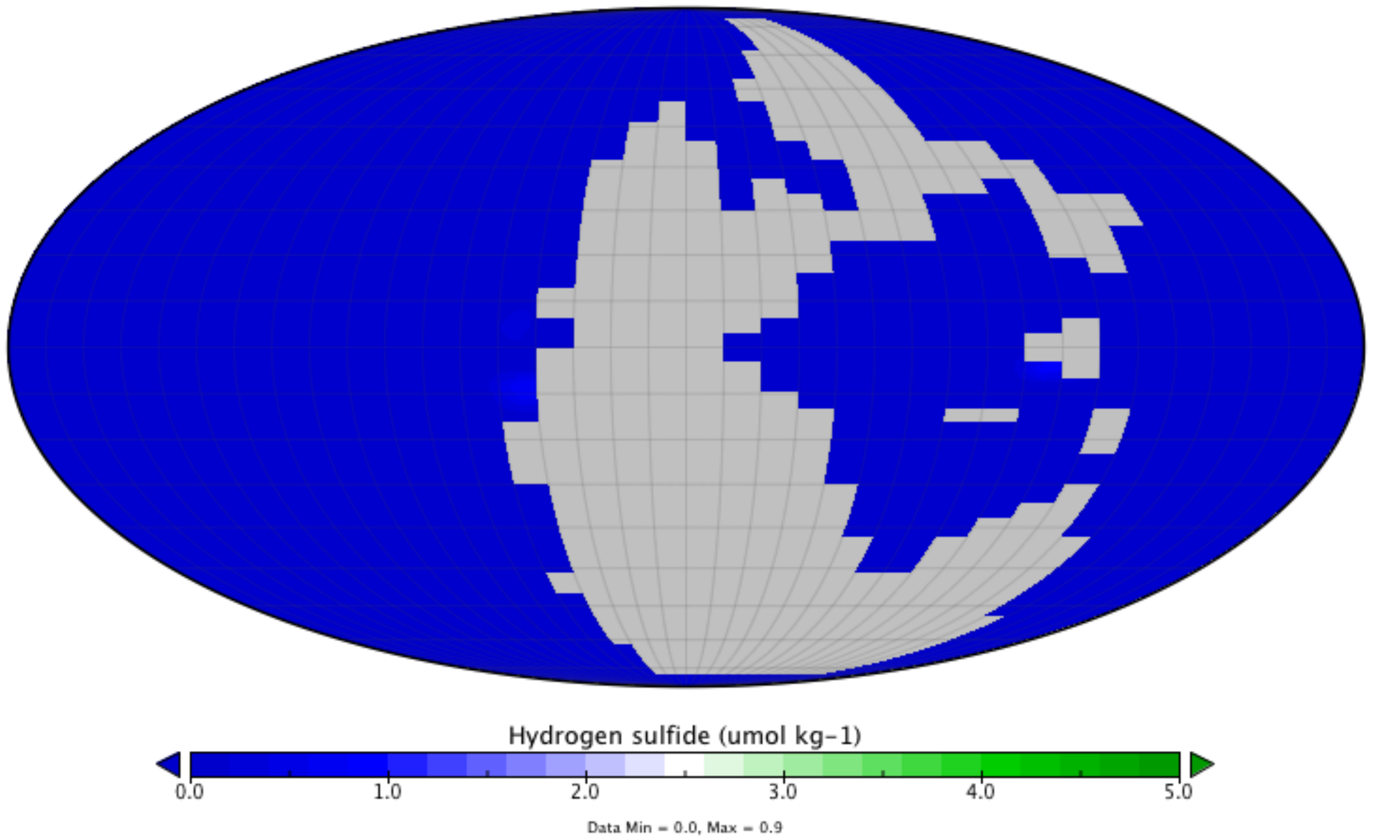
1x PO_4^{3-}

Surface Ocean H_2S



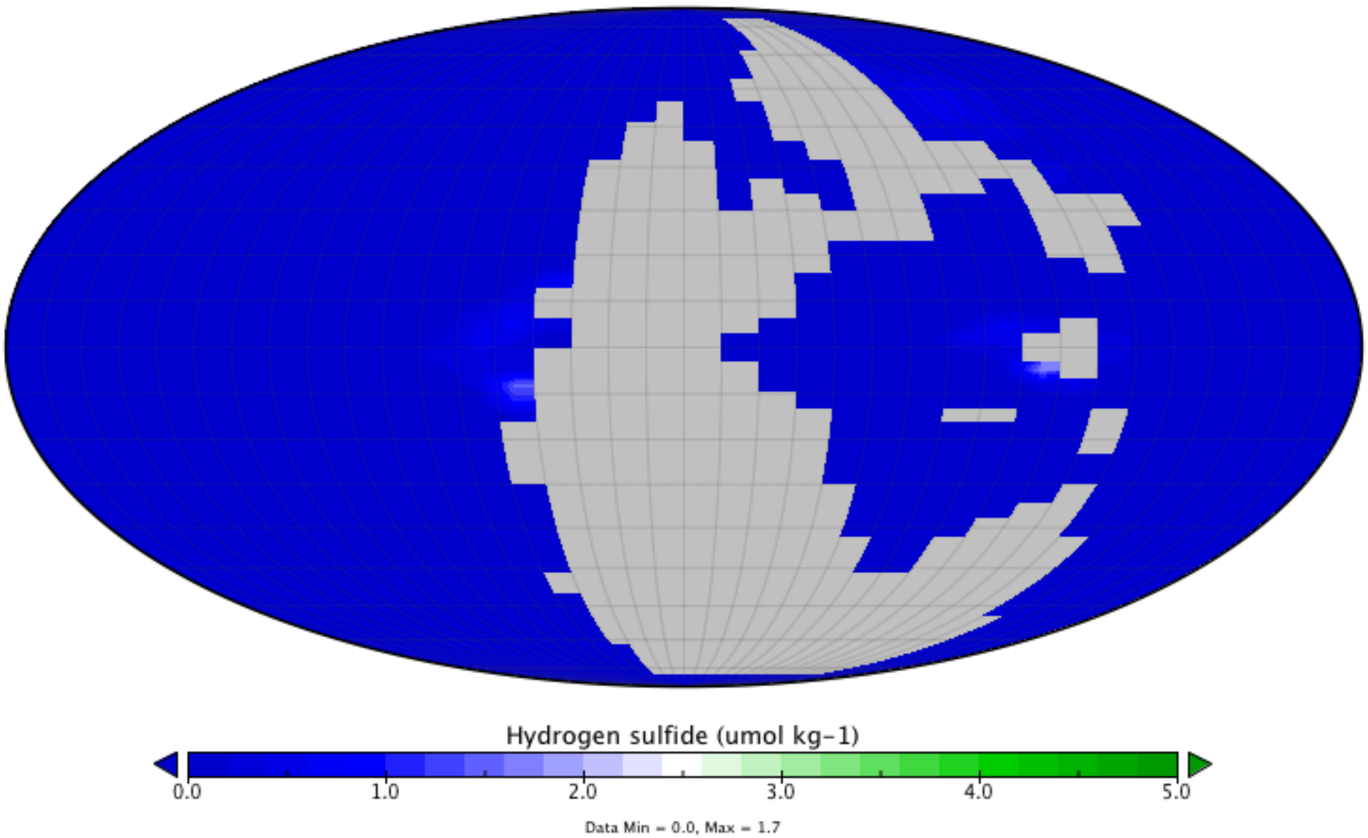
2x PO_4^{3-}

Surface Ocean H_2S



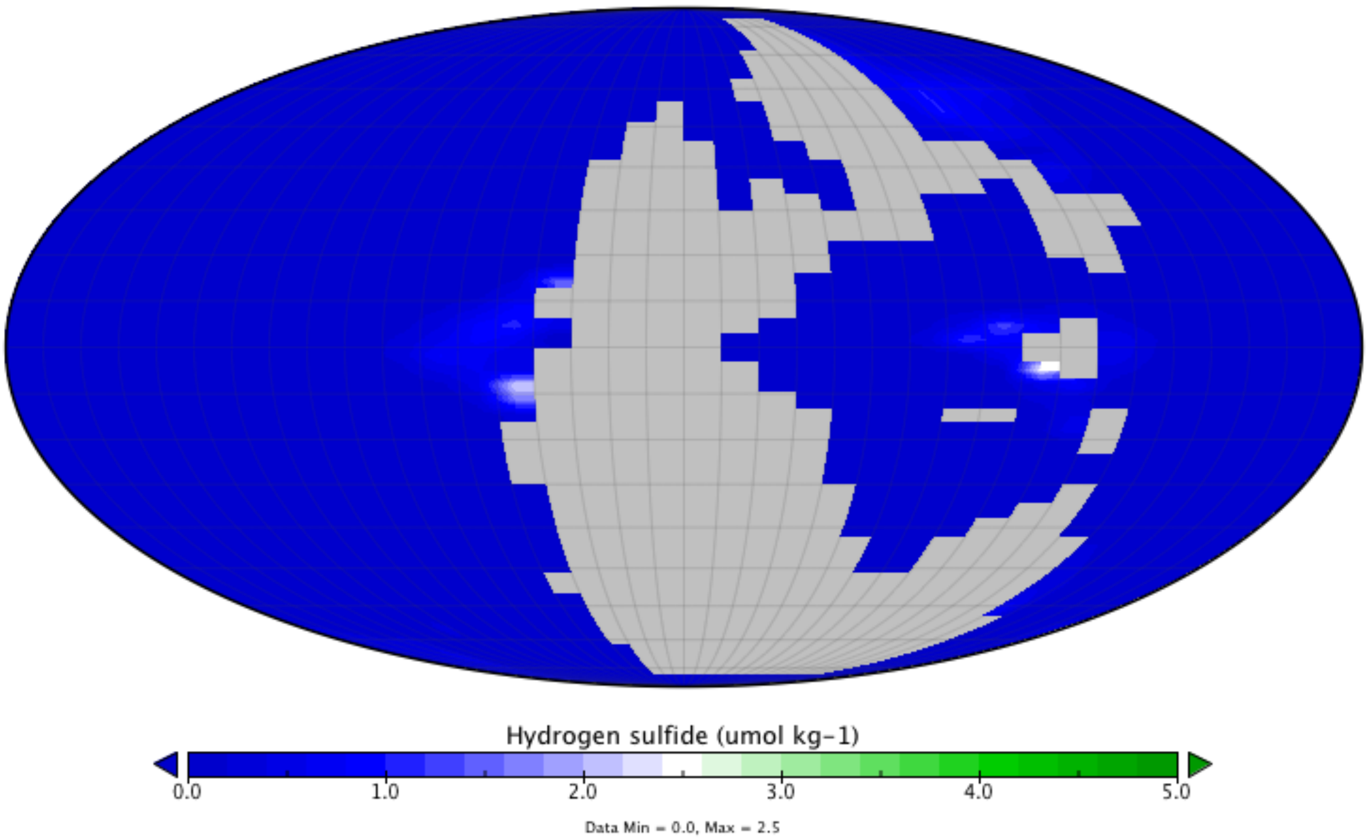
3x PO_4^{3-}

Surface Ocean H_2S



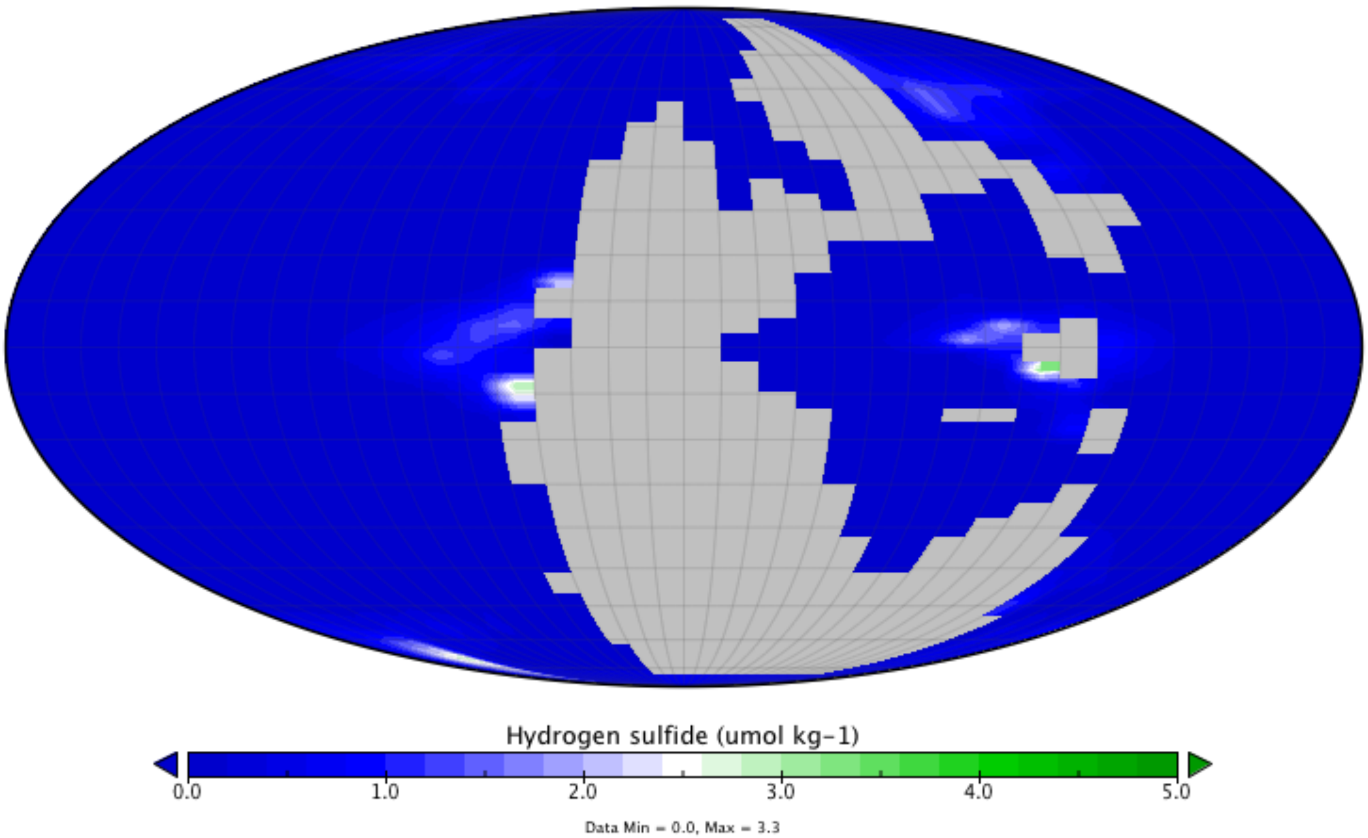
4x PO_4^{3-}

Surface Ocean H_2S



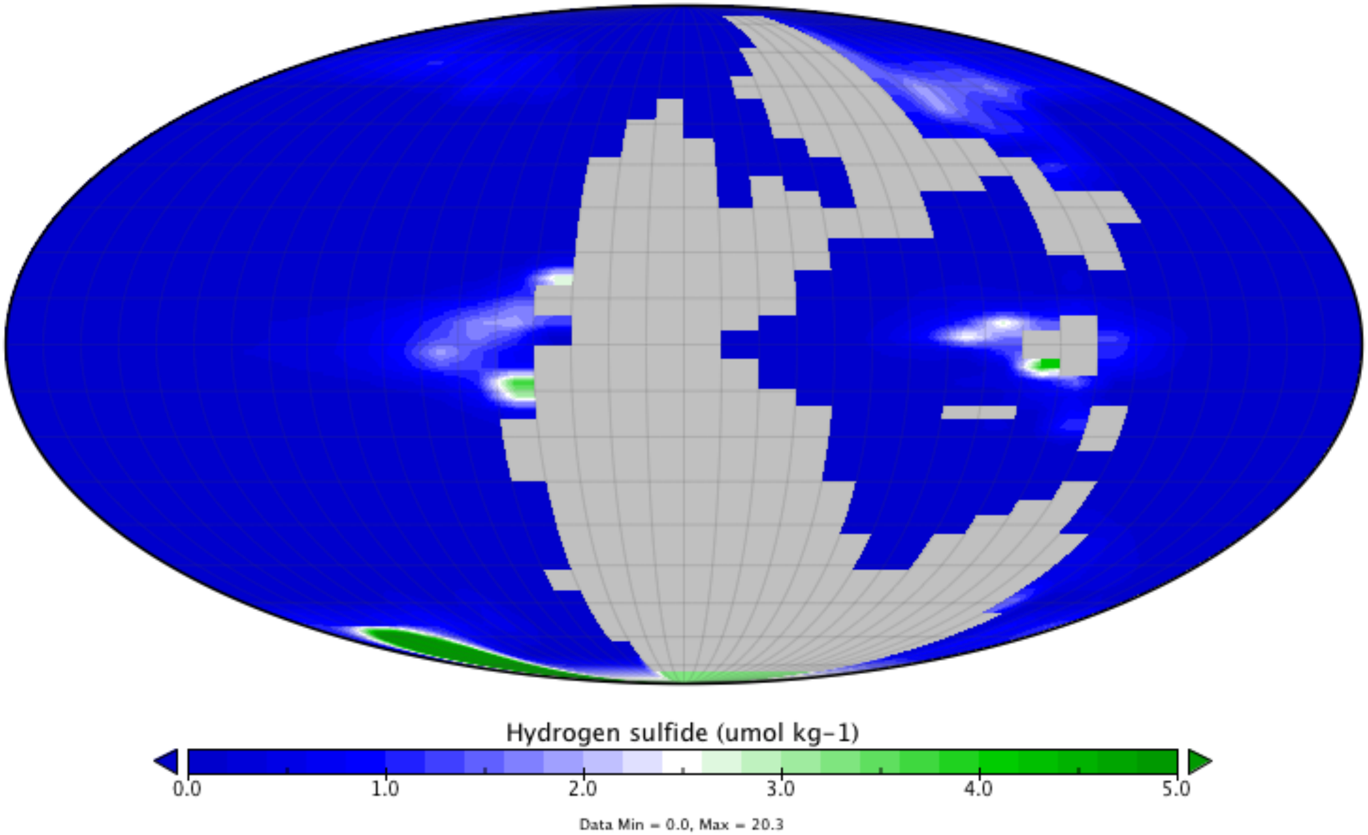
5x PO_4^{3-}

Surface Ocean H_2S



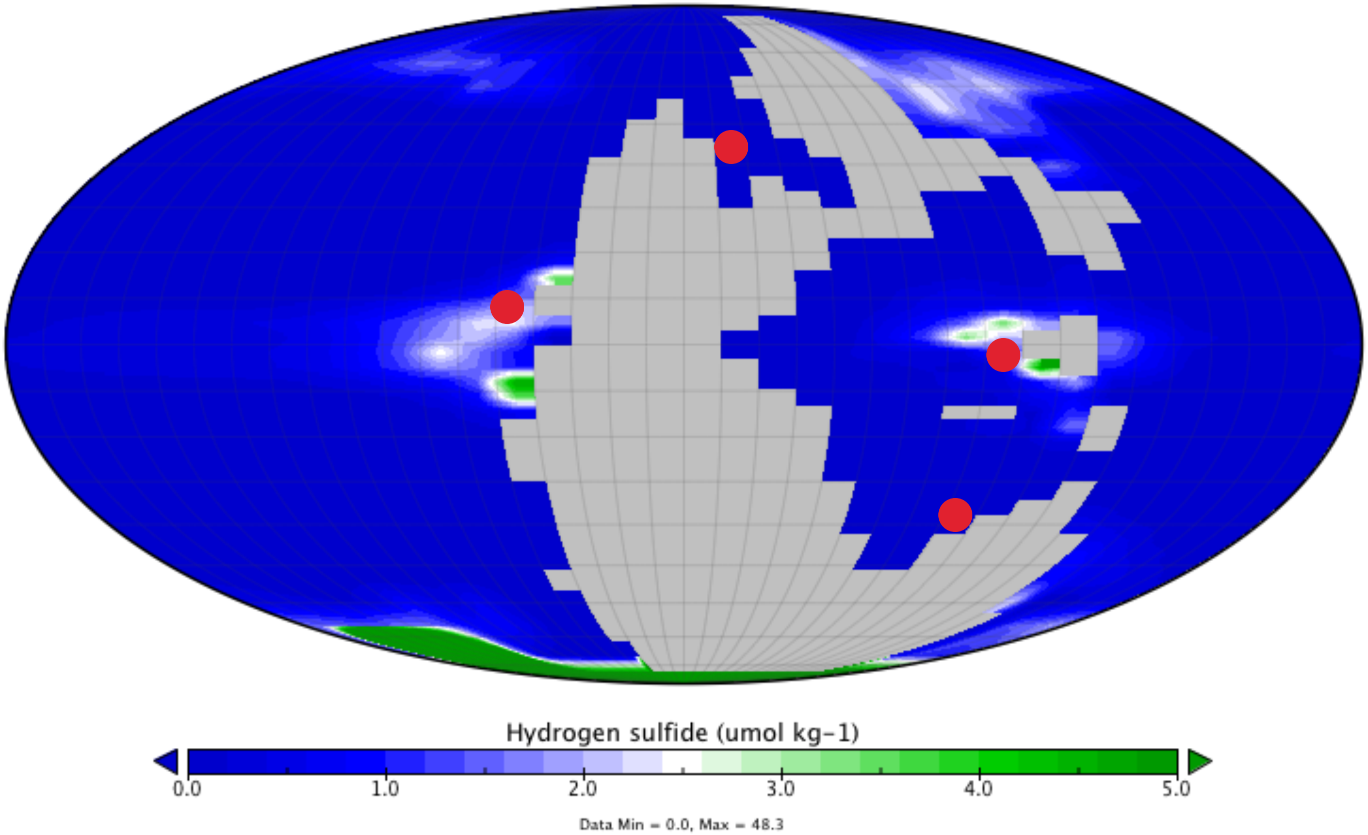
6x PO_4^{3-}

Surface Ocean H_2S



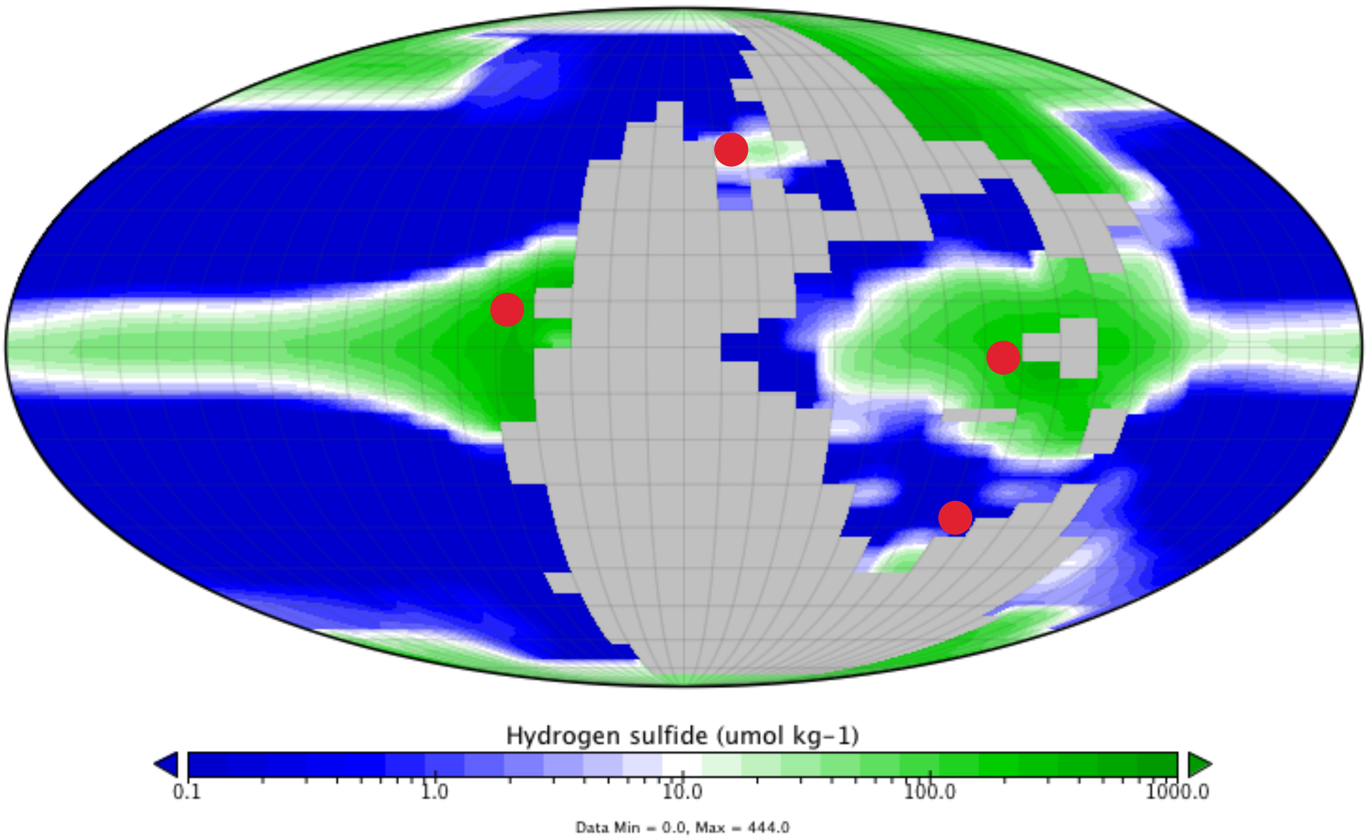
7x PO_4^{3-}

Surface Ocean H_2S



8x PO_4^{3-}

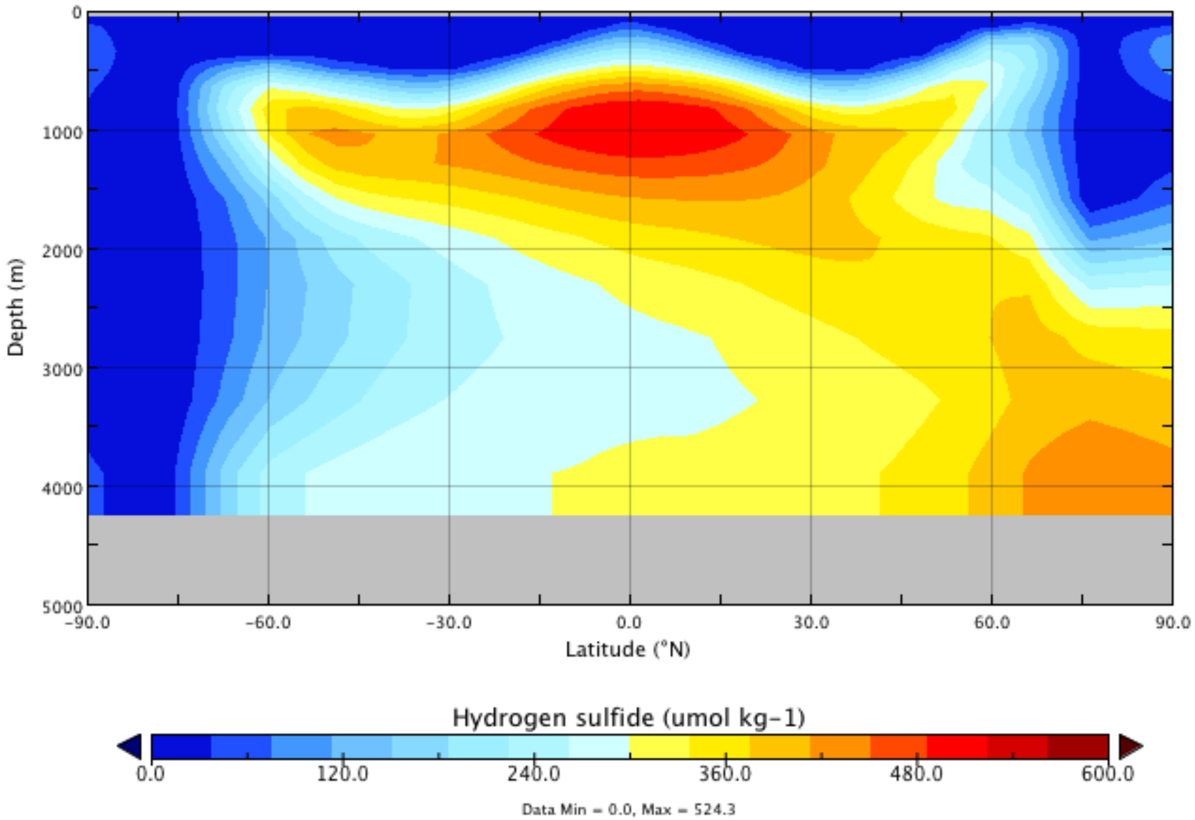
Surface Ocean H_2S



80-175 m depth

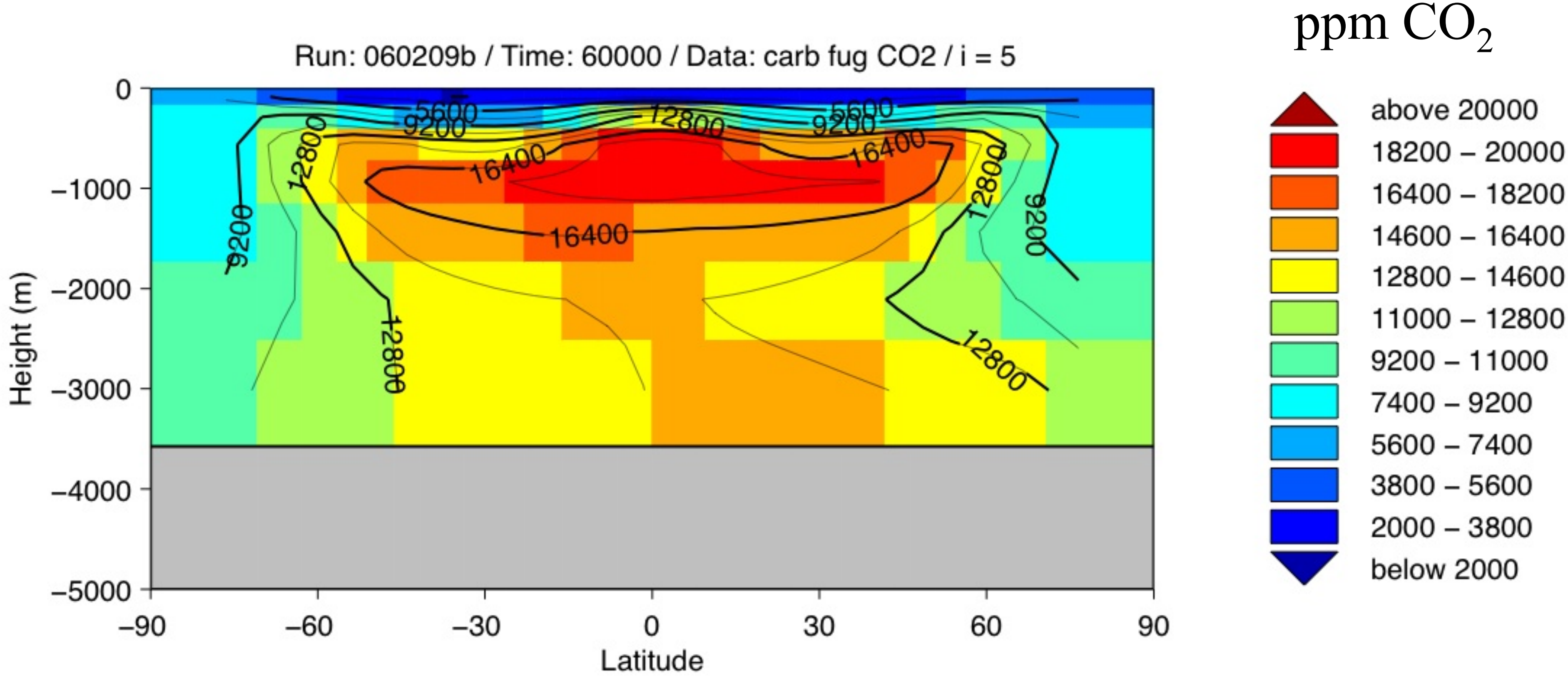
8x PO_4^{3-}

Hydrogen Sulfide



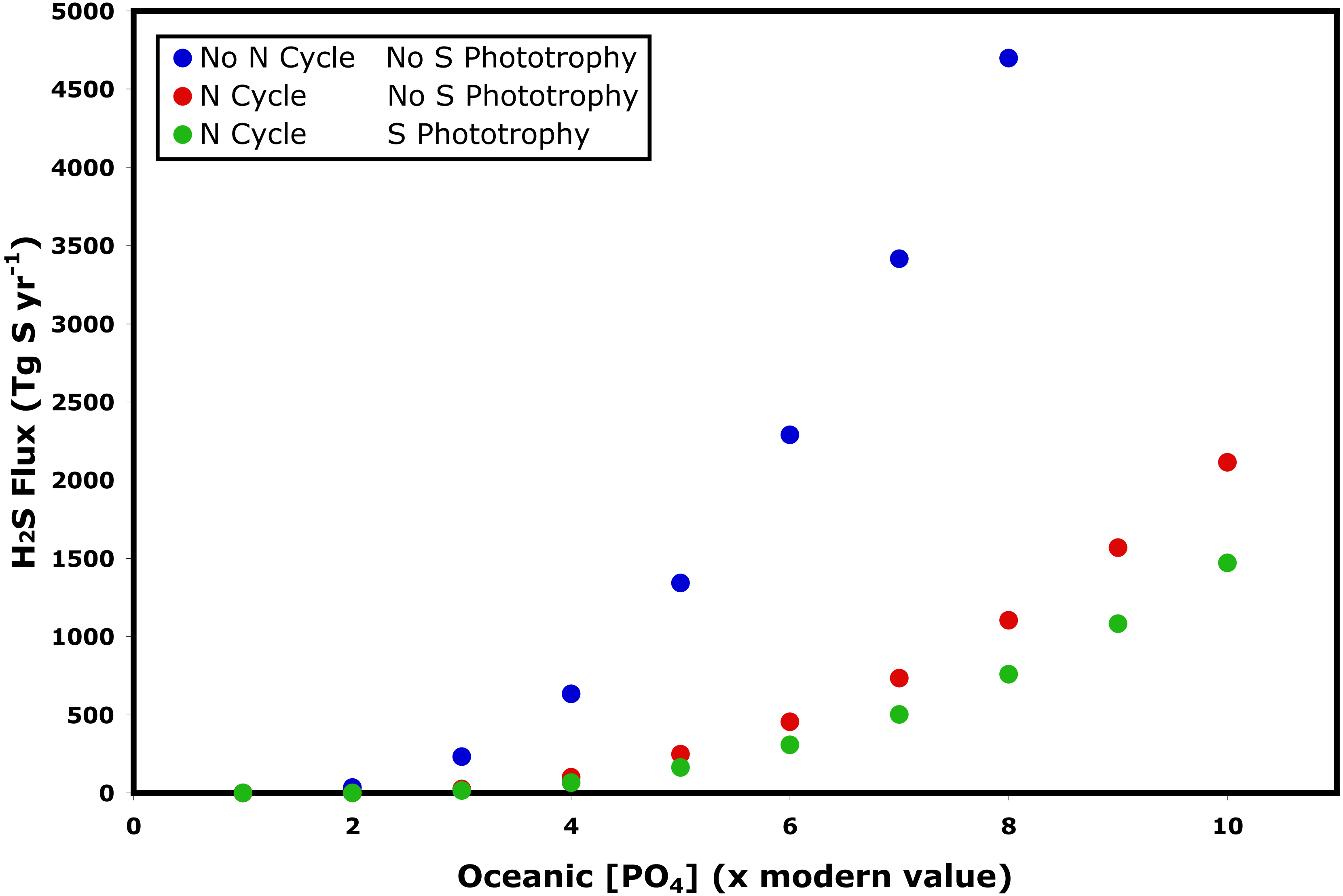
Panthalassic ocean

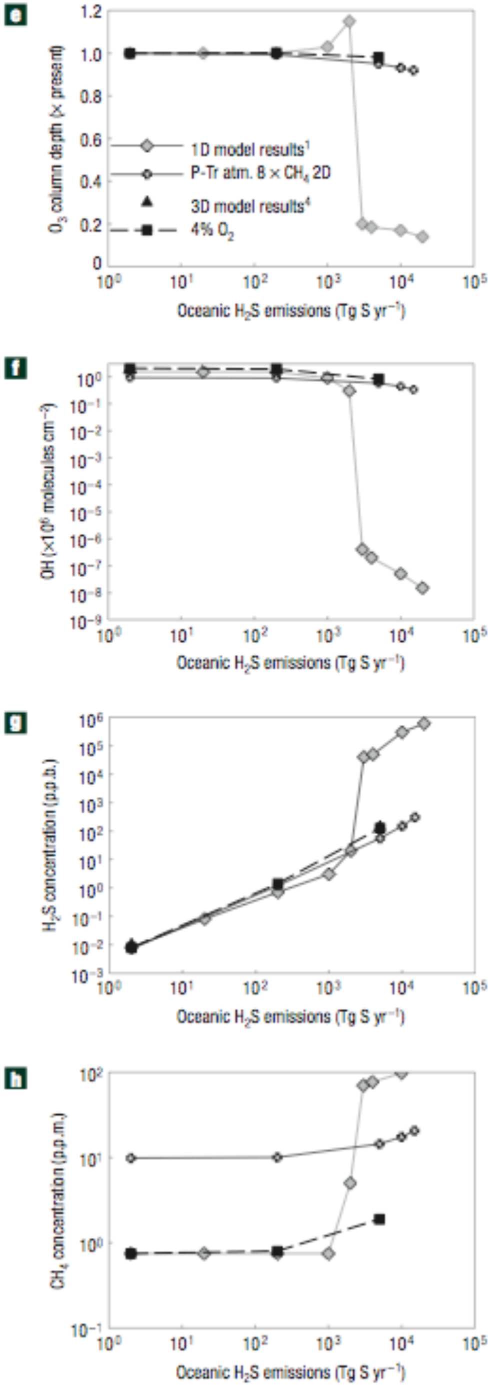
8x PO_4^{3-}



ppm CO_2
Run: 060209b / Time: 60000 / Data: carb fug CO2 / i = 5
Height (m)
Latitude
above 20000
18200 – 20000
16400 – 18200
14600 – 16400
12800 – 14600
11000 – 12800
9200 – 11000
7400 – 9200
5600 – 7400
3800 – 5600
2000 – 3800
below 2000

More realistic models have reduced fluxes





O_3

OH

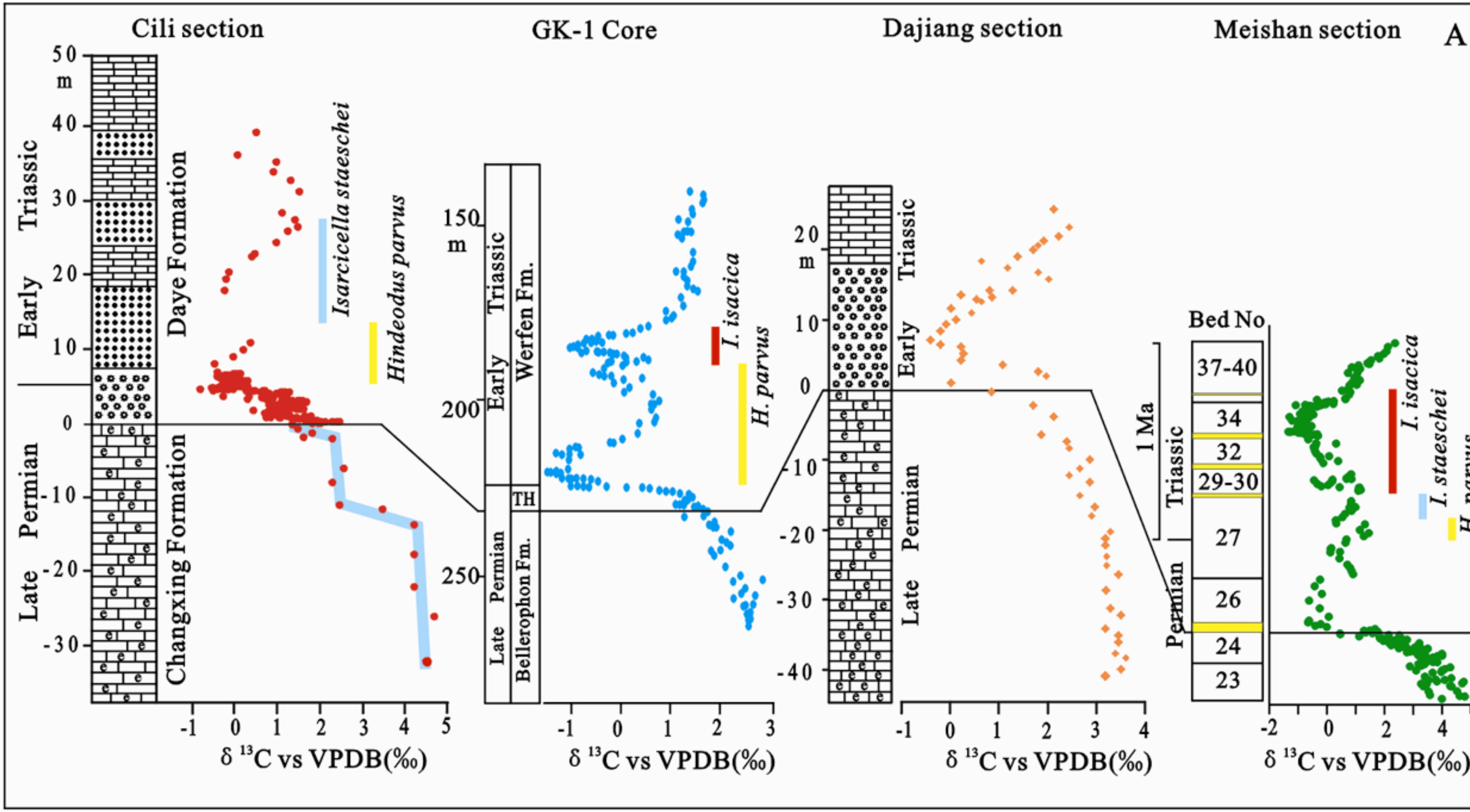
H_2S

CH_4

Harfoot et al. (2008)

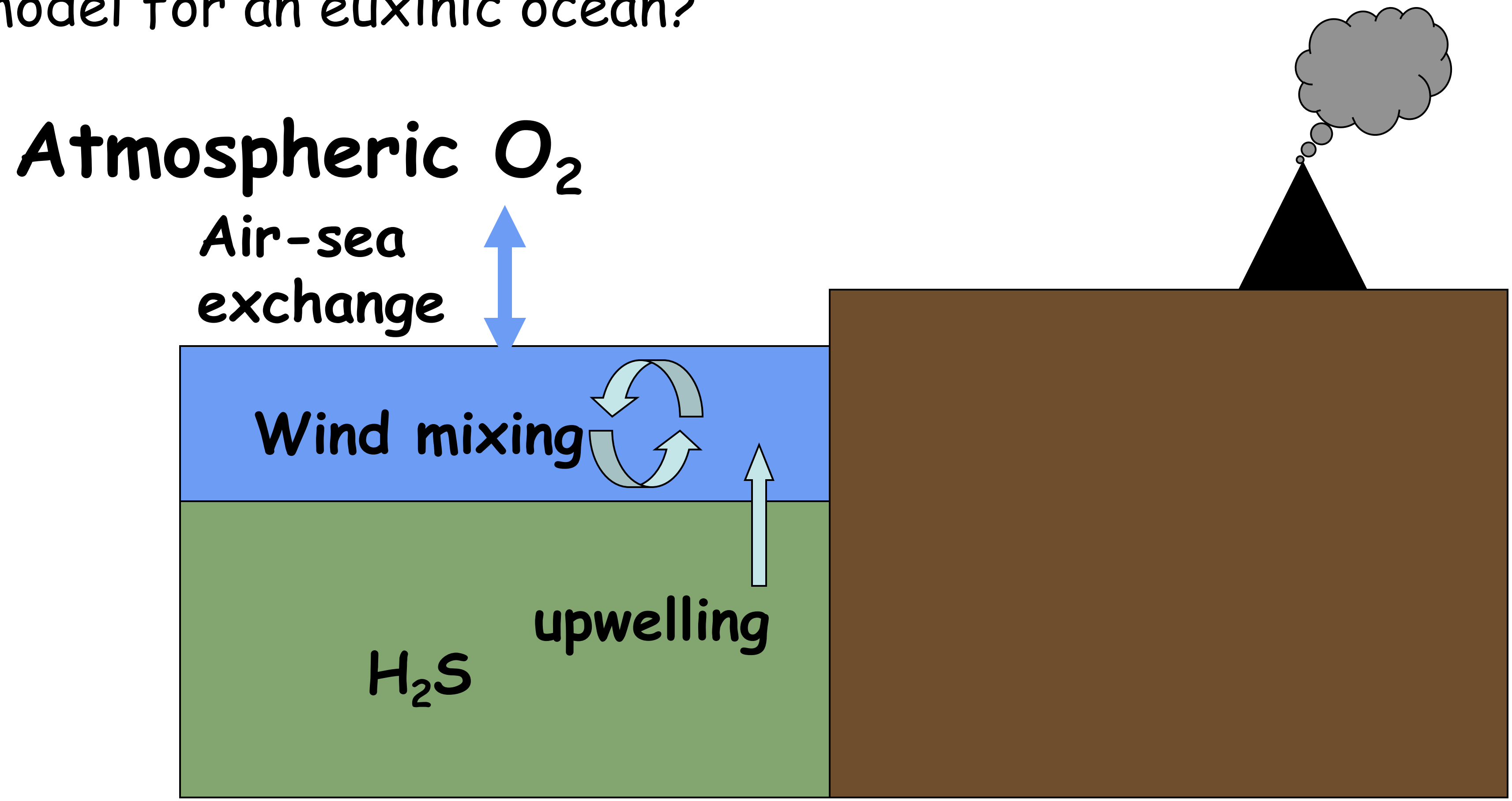
Is the H_2S Hypothesis "Dead"?

- More sophisticated ocean models produce less H_2S in surface waters (but PZE still widespread)
- More sophisticated atmospheric models yield much lower H_2S values and no ozone depletion at similar fluxes to earlier work (chronic rather than acute stress on biota)



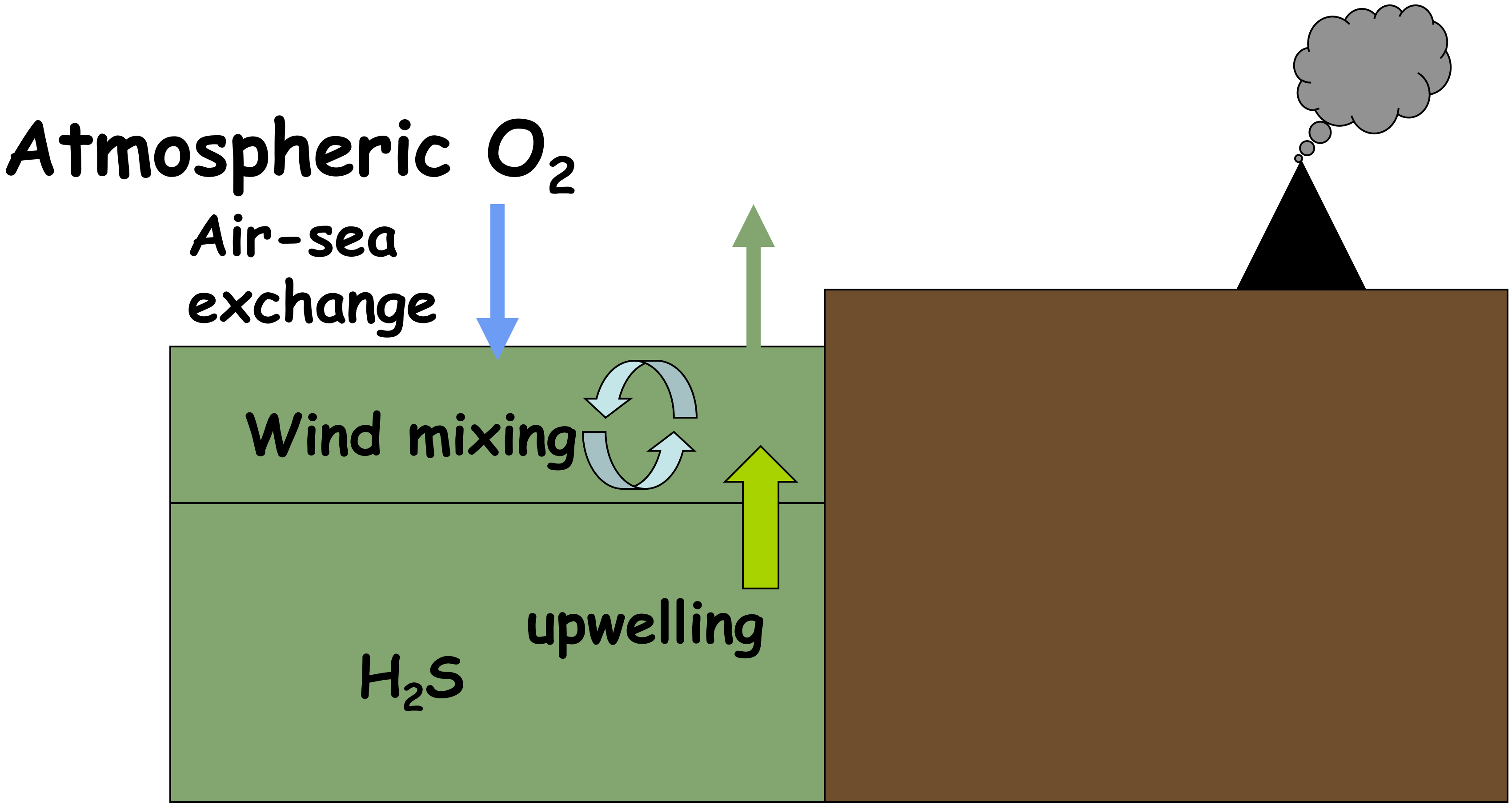
Guo et al. (in press, EPSL)

Keeping euxinia at depth: is the Black Sea the appropriate model for an euxinic ocean?



Wind-mixed layer oxygenated today (e.g., in Black Sea) because supply of O_2 across air-sea interface exceeds upwelling of H_2S

Upwelling flux of H_2S comes to exceed in-mixing of O_2



Because of increasing [H_2S] and/or decreasing atmospheric pO_2