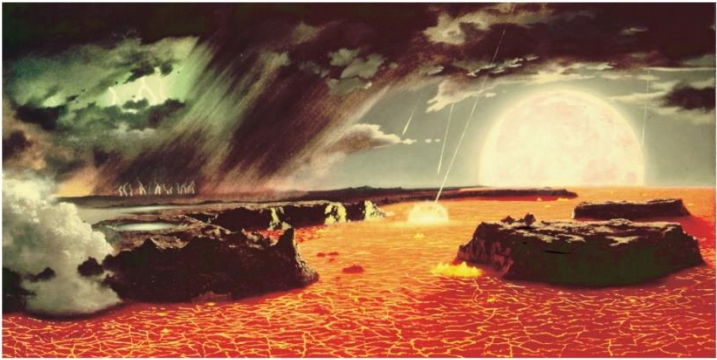


# 7. Great Oxygenation Event

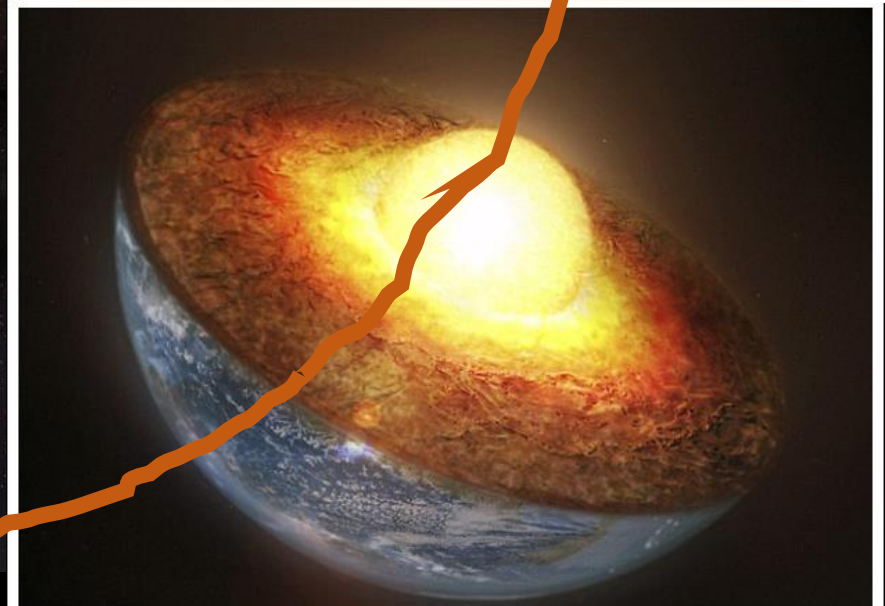
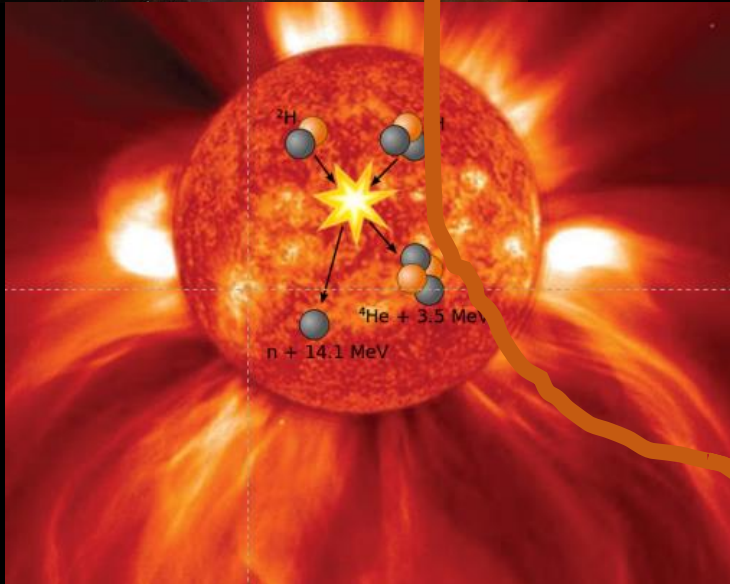
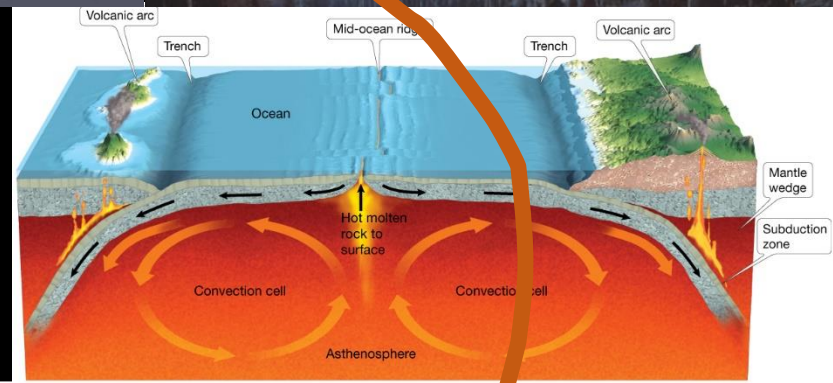
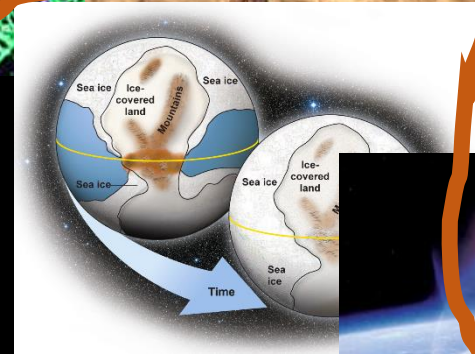
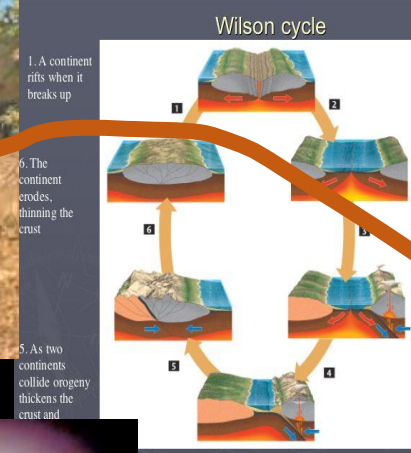
Hadean →



Early Life → Banded Iron Formations





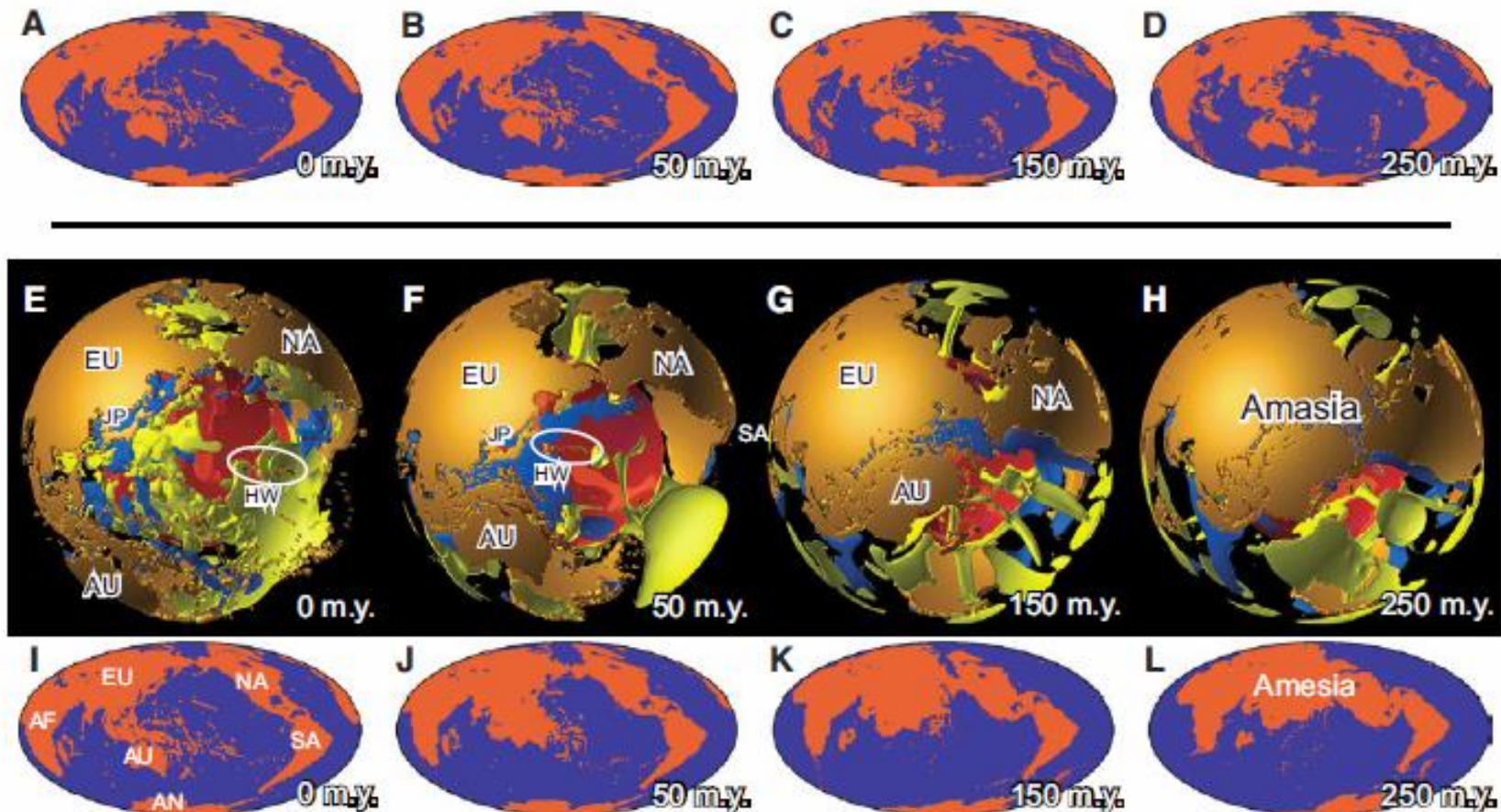




# Formation of a future supercontinent through plate motion–driven flow coupled with mantle downwelling flow

Masaki Yoshida

Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine–Earth Science and Technology (JAMSTEC), 2-15 Natsushima-cho, Yokosuka, Kanagawa 237-0061, Japan



# Hadean (hell on Earth) 4.6-4.0 Ga



~1 Ga before life

# Multiple working hypotheses on Life's Origins

## 1) Extraterrestrial Origins:

Life did not originate here, but landed here

## 2) Warm Little Pond or The proverbial 'primordial soup' (Urey-Miller Experiment)

## 3) Black Smokers: thermophiles, chemosynthesis, and methanogens again, oceans are uniform and distribute resources these are more like specialized life (extremophiles)

## 4) Soil (really the *same* as 2)

# How do complex Chemicals form?

-Urey-Miller Experiment

Circa 1954

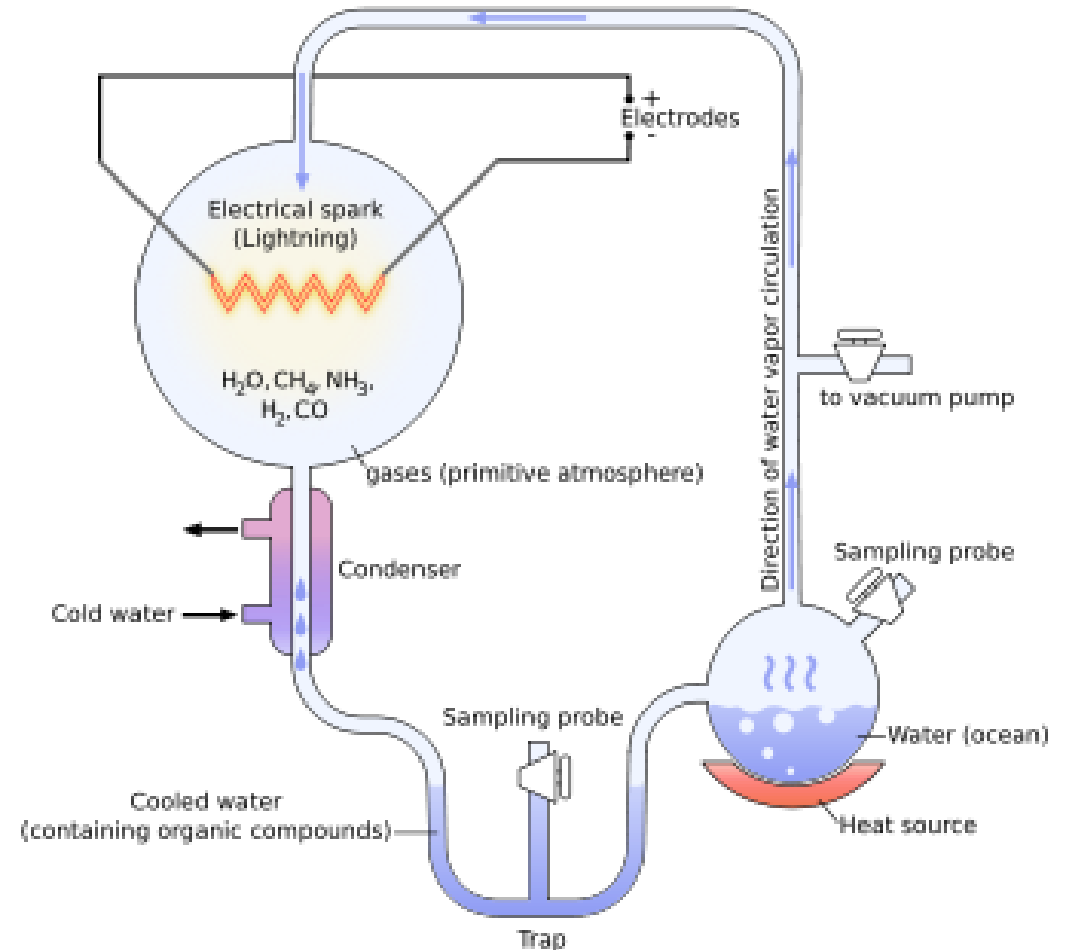
(again in 1983, then again in 2010)

Produced 25 Amino Acids!  
(probably more at low concentrations)

TIME!

~1 Ga

Disorganized to organized





# Hypothesis: Life's Origins in Soil

Obvious spiritual resonance...  
But scientifically:

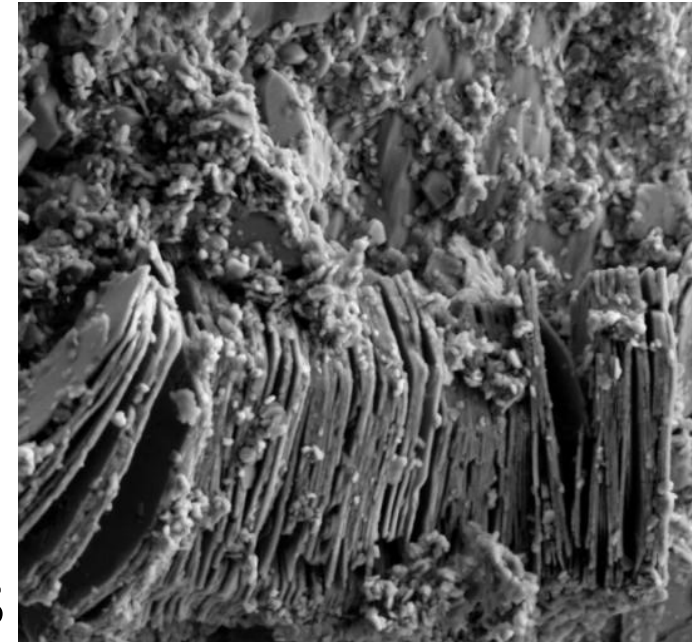
Absorb moisture and organic matter

Clays Create a template for loosely bound cations  
(organic and otherwise)

Replicate—the crystal gene

Soil IS 'the warm little pond'

SEM image of Clay



Journal of Theoretical Biology

Volume 10, Issue 1, January 1966, Pages 53-88



The origin of life and the nature of the primitive  
gene

A.G. Cairns-Smith

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[https://doi.org/10.1016/0022-5193\(66\)90178-0](https://doi.org/10.1016/0022-5193(66)90178-0)

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Abstract

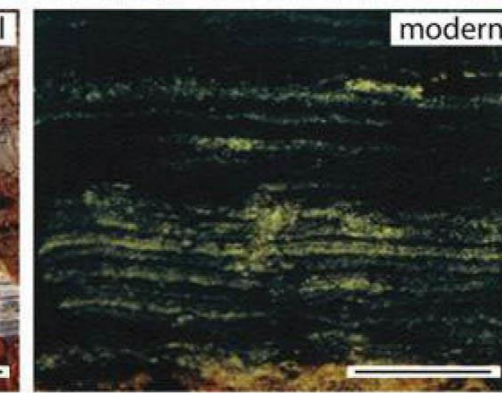
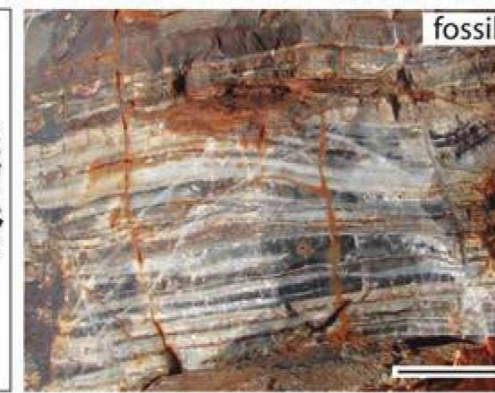
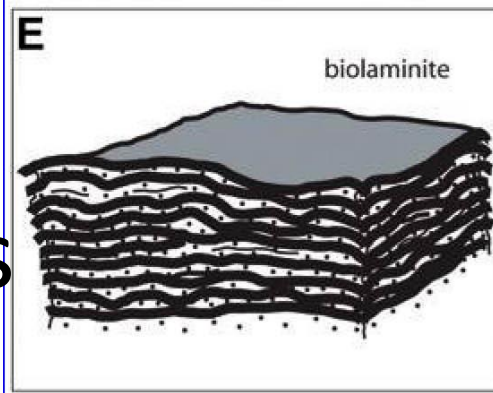
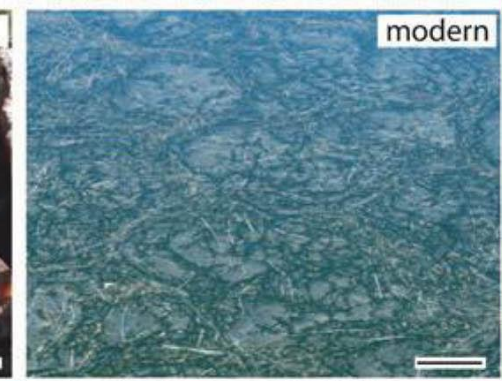
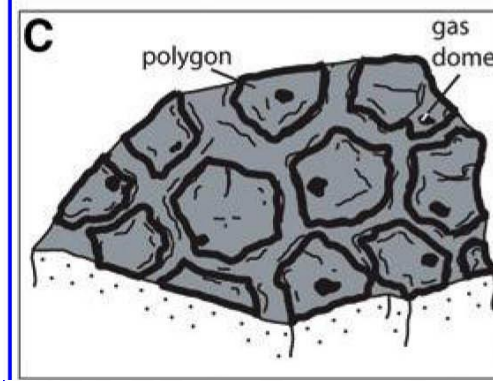
It is proposed that life on earth evolved through natural selection from inorganic crystals.

# What we observe...

## Archean 4.0-2.5 Ga

### 3.48 Ga

## Microbial Induced Sedimentary Structures



### ARTICLE

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**OPEN**

## Earliest signs of life on land preserved in ca. 3.5 Ga hot spring deposits

Tara Djokic<sup>1,2</sup>, Martin J. Van Kranendonk<sup>1,2,3</sup>, Kathleen A. Campbell<sup>4</sup>, Malcolm R. Walter<sup>1</sup> & Colin R. Ward<sup>5</sup>



# Atmospheric oxygenation three billion years ago

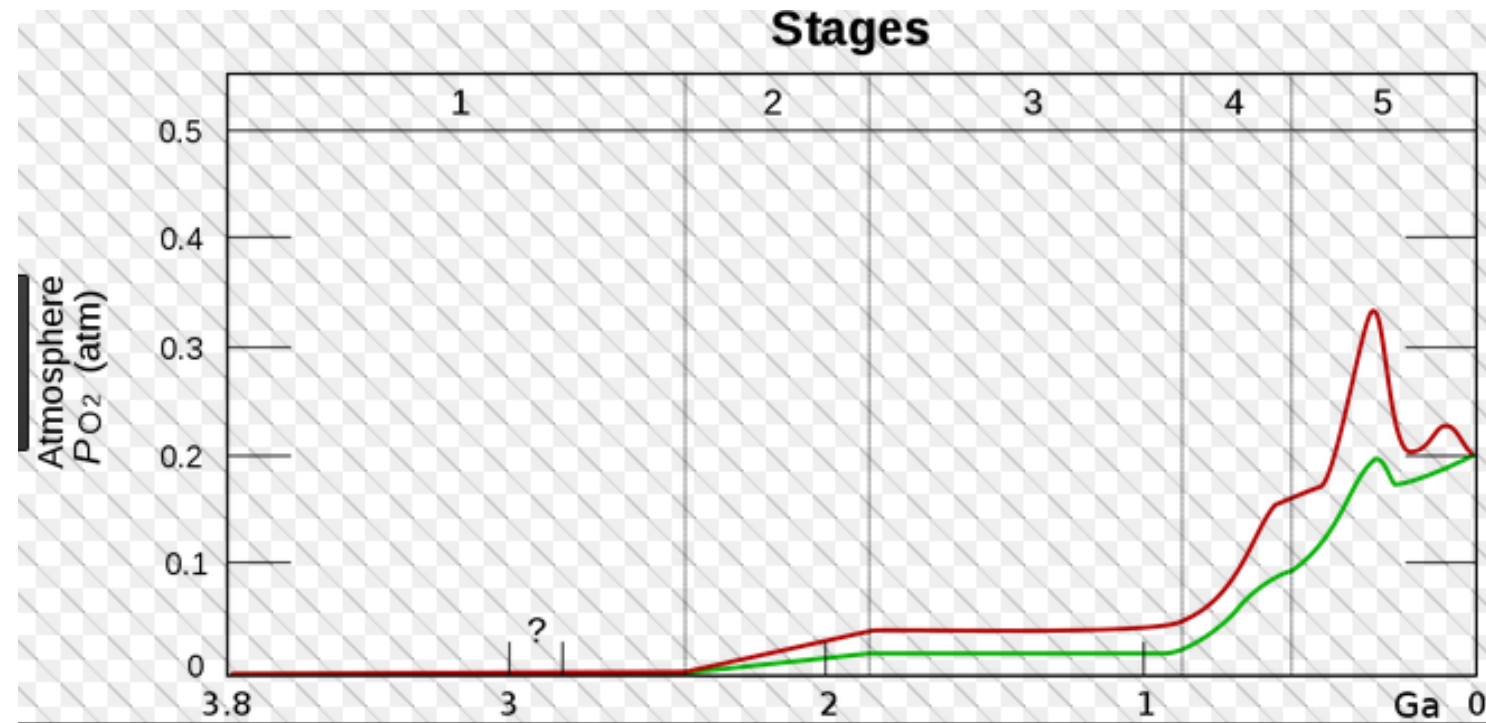
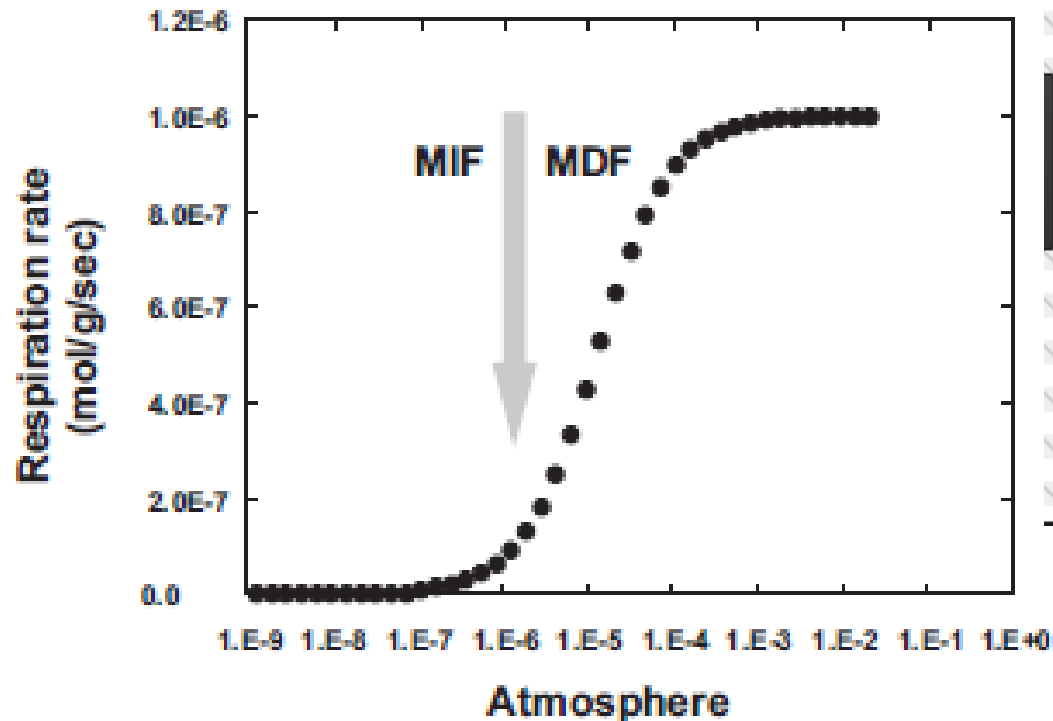
Sean A. Crowe<sup>1†\*</sup>, Lasse N. Døssing<sup>1,2\*</sup>, Nicolas J. Beukes<sup>3</sup>, Michael Bau<sup>4</sup>, Stephanus J. Kruger<sup>3</sup>, Robert Frei<sup>2</sup> & Donald E. Canfield<sup>1</sup>

It is widely assumed that atmospheric oxygen concentrations remained persistently low (less than  $10^{-5}$  times present levels) for about the first 2 billion years of Earth's history<sup>1</sup>. The first long-term oxygenation of the atmosphere is thought to have taken place around 2.3 billion years ago, during the Great Oxidation Event<sup>2,3</sup>. Geochemical indications of transient atmospheric oxygenation, however, date back to 2.6–2.7 billion years ago<sup>4–6</sup>. Here we examine the distribution of chromium isotopes and redox-sensitive metals in the approximately 3-billion-year-old Nsuzi palaeosol and in the near-contemporaneous Ijzermyn iron formation from the Pongola Supergroup, South Africa. We find extensive mobilization of redox-sensitive elements through oxidative weathering. Furthermore, using our data we compute a best minimum estimate for atmospheric oxygen concentrations at that time of  $3 \times 10^{-4}$  times present levels. Overall, our findings suggest that there were appreciable levels of atmospheric oxygen about 3 billion years ago, more than 600 million years before the Great Oxidation Event and some 300–400 million years earlier than previous indications for Earth surface oxygenation.

Sometime during the  
Late Archean, bacteria  
Harnesses photosynthesis

# Reconstructing Earth's surface oxidation across the Archean-Proterozoic transition

Qingjun Guo<sup>1,2</sup>, Harald Strauss<sup>2</sup>, Alan J. Kaufman<sup>2,3</sup>, Stefan Schröder<sup>4,5</sup>, Jens Gutzmer<sup>4,6</sup>, Boswell Wing<sup>7</sup>, Margaret A. Baker<sup>8</sup>, Andrey Bekker<sup>9</sup>, Qusheng Jin<sup>10</sup>, Sang-Tae Kim<sup>8</sup>, and James Farquhar<sup>3</sup>





Surface water with  
blue/green algae



Fe ions  
from  
surface  
water  
gathering

+

O<sub>2</sub> ions from  
blue/green  
algae  
photosynthetic

=

$\text{Fe}_3\text{O}_4$

Sinks to the  
sea floor.



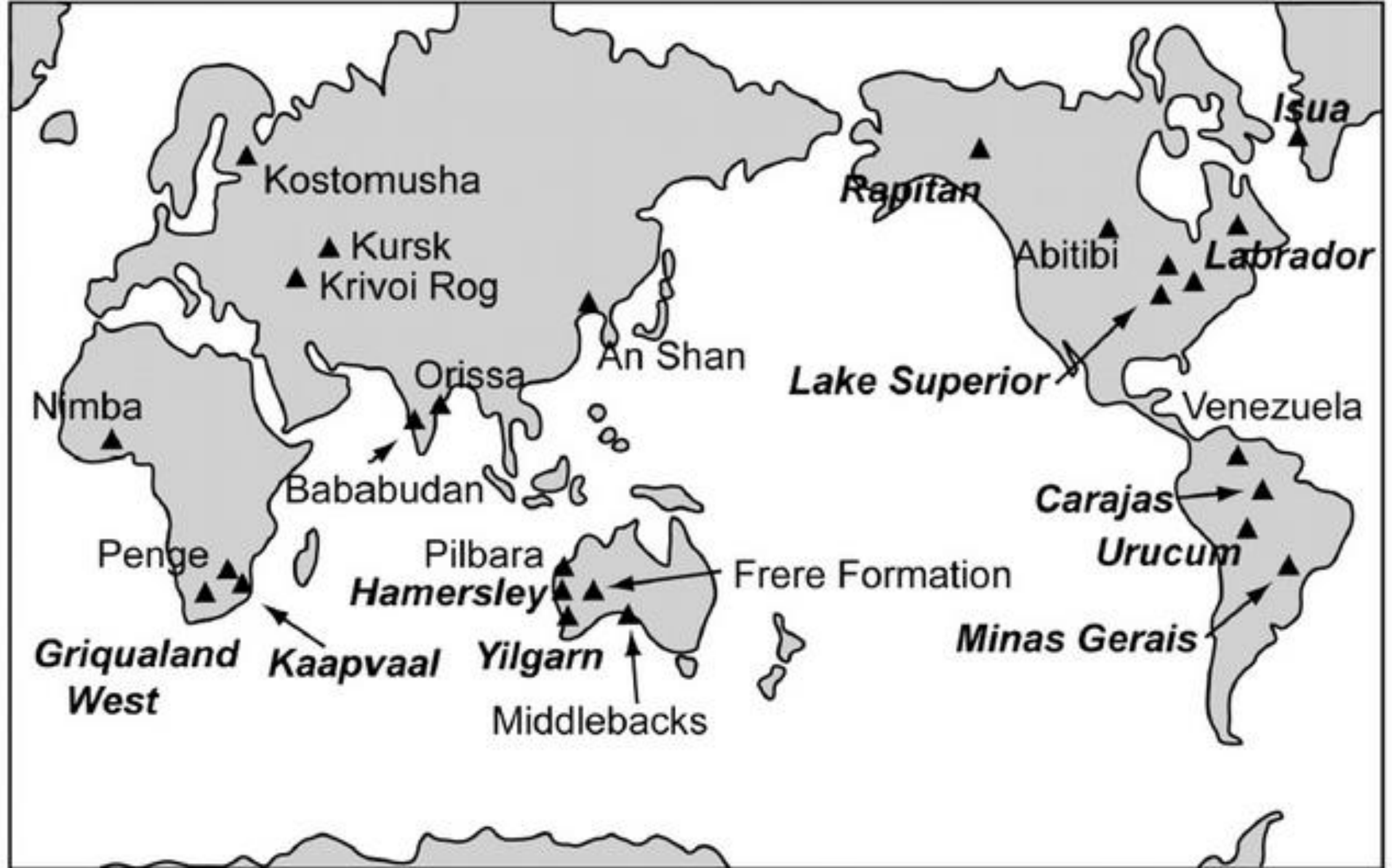


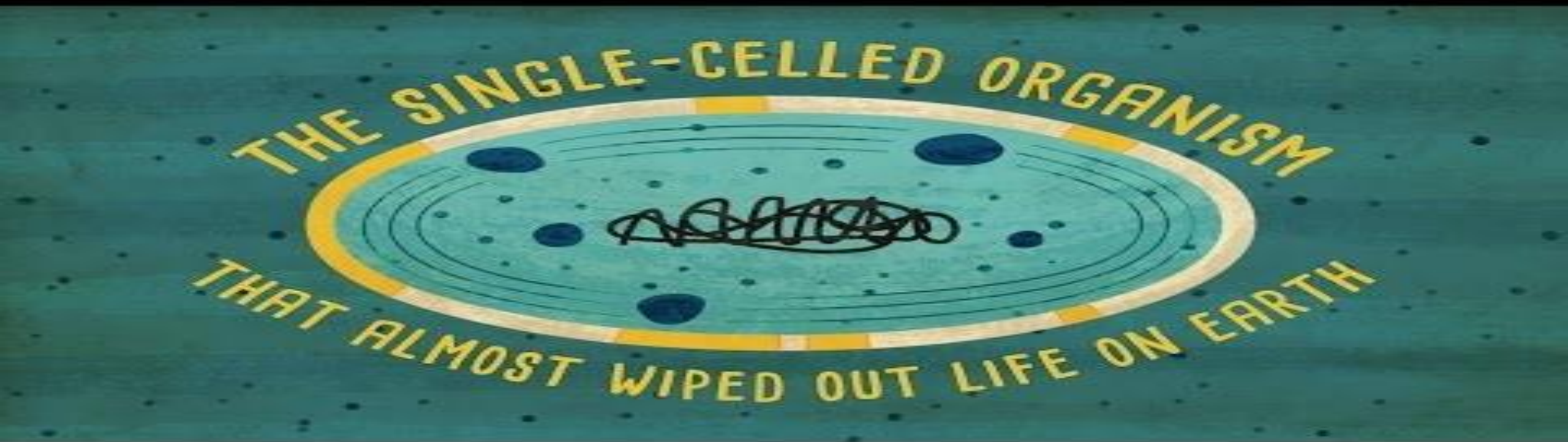
# Banded Iron Formation (BIF)

## Rise of Oxygen Sequestered in Ocean









<https://youtu.be/dO2xx-aeZ4w>



Dimitri A. Sverjensky\* and Namhey Lee\*

1811-5209/10/0006-0031\$2.50 DOI: 10.2113/gselements.6.1.31

**B**efore the Great Oxidation Event (GOE), at ~2.4 Ga, the mineralogical record of the near-surface continental environment indicates a low partial pressure of oxygen during weathering, which restricted many elements to a low oxidation state and limited the number of possible minerals formed from these elements. Calculations show that local pulses in the production of O<sub>2</sub> by photosynthesis could mobilize some metals (e.g. Mo and Re, but not U), but this O<sub>2</sub> would be completely consumed. After the GOE, many elements could occur in one or more oxidized forms in minerals in the near-surface environment. This development resulted in an explosive growth in the diversification of minerals.

# Evolution of **Minerals**

---

BY ROBERT M. HAZEN

Looking at the mineral kingdom through the lens  
of deep time leads to a startling conclusion:  
most mineral species owe their existence to life

# Today's dose of Violence brought to you by: Lynn Margulis 1938 – 2011 American Biologist and “Science's Unruly Earth Mother”



The notion of saving the planet has nothing to do with intellectual honesty or science. The fact is that the planet was here long before us and will be here long after us. The planet is running fine. What people are talking about is saving themselves and saving their middle-class lifestyles and saving their cash flow.

— Lynn Margulis —

AZ QUOTES

