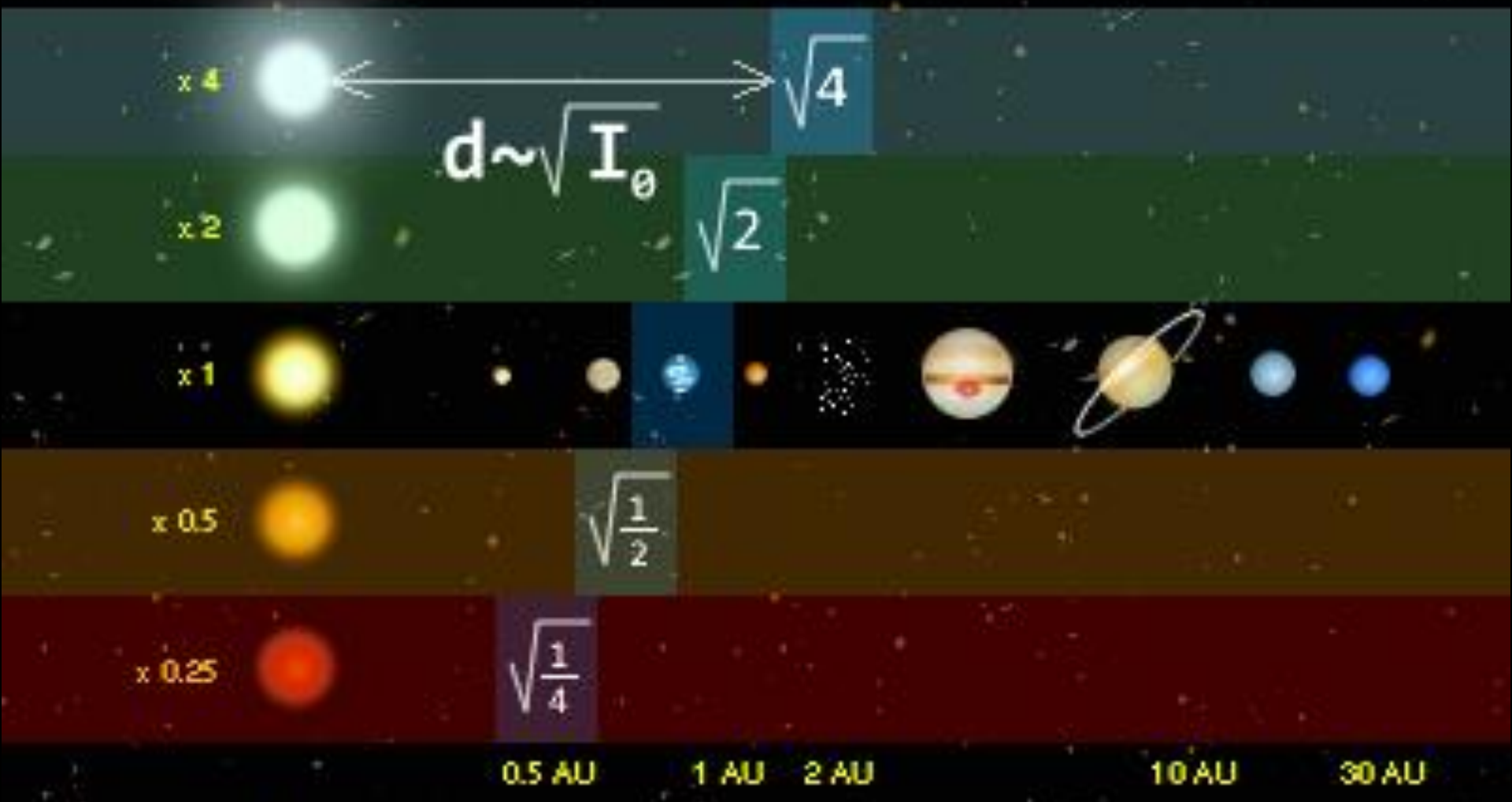
ASTR/GEOL-2040: Search for life in the Universe: Lecture 13

- CO_2 on Venus
- Plate tectonics
- BIFs and GOE

Axel Brandenburg
(Office hours: Mondays 2:30 – 3:30 in X590 and Wednesdays 11-12 in D230)

Habitable zone

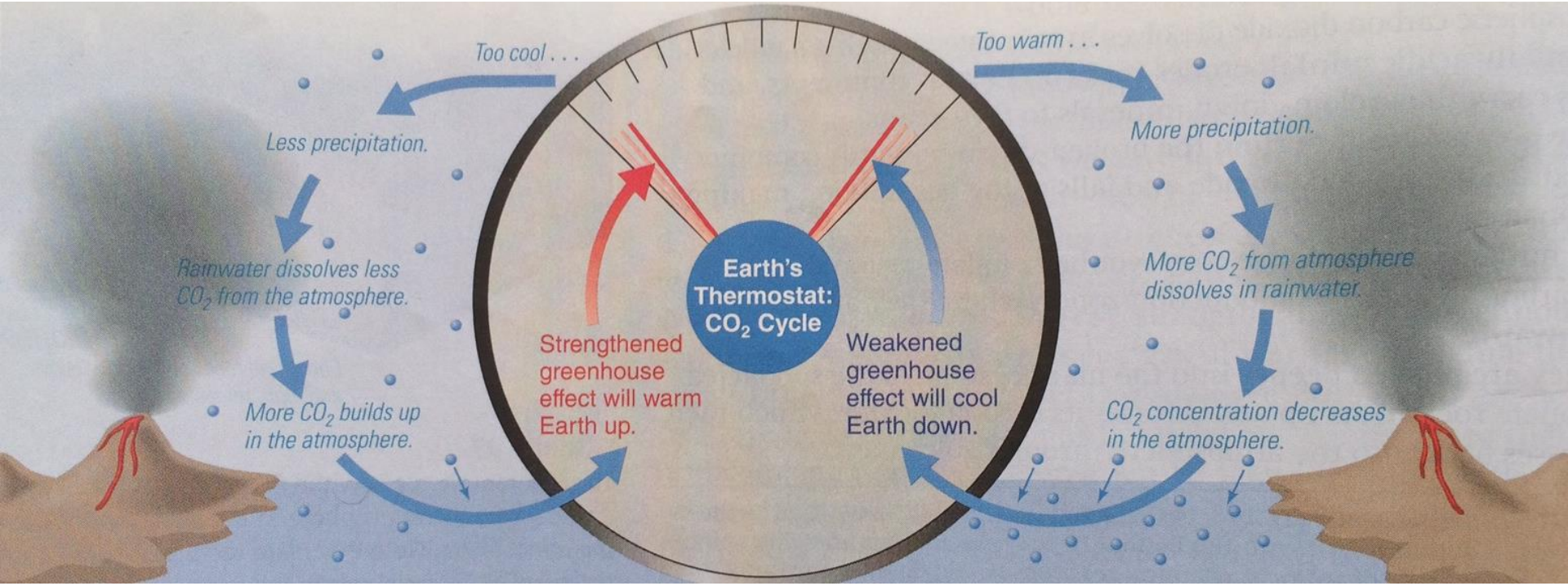


Other factors determining Earth's temperature

- Greenhouse gases, e.g., CO_2
  - Others? Yes: CH_4 and H_2O
- Sources & sinks of CO_2
  - Weathering
  - Volcanoes

The CO_2 thermostat

CO_2 high, warm, more rain

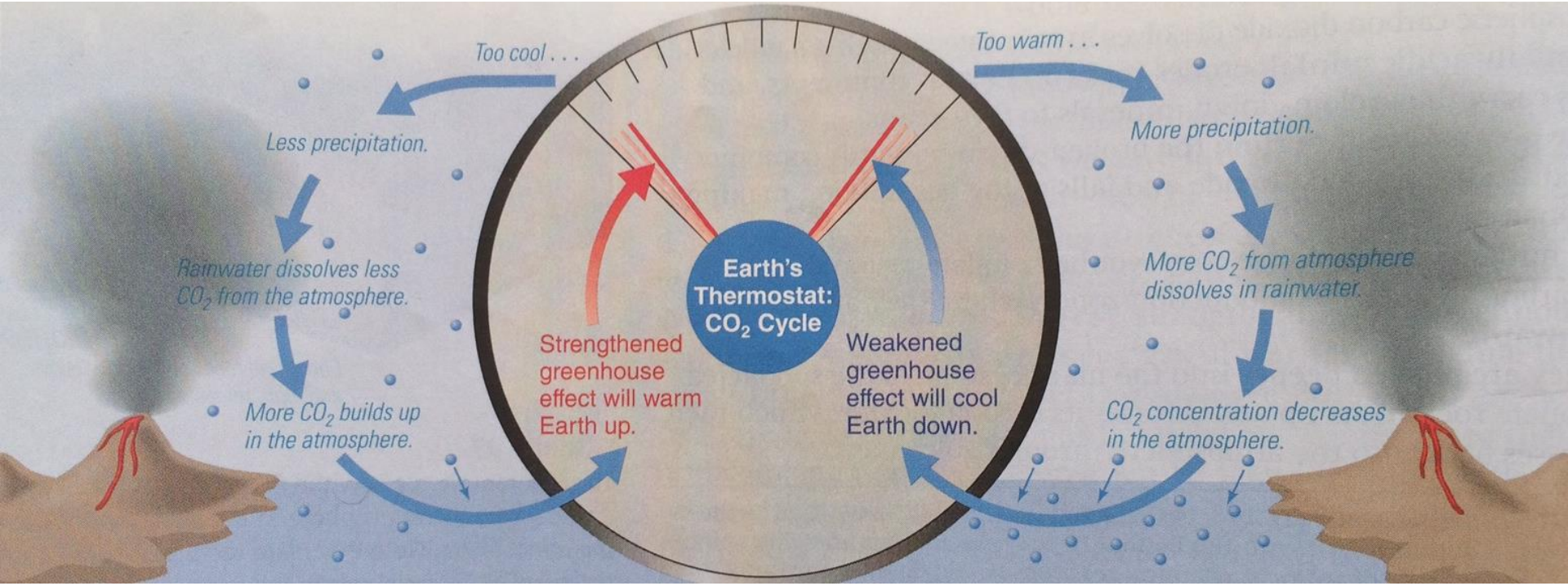


atmospheric CO_2 reduced

The CO_2 thermostat

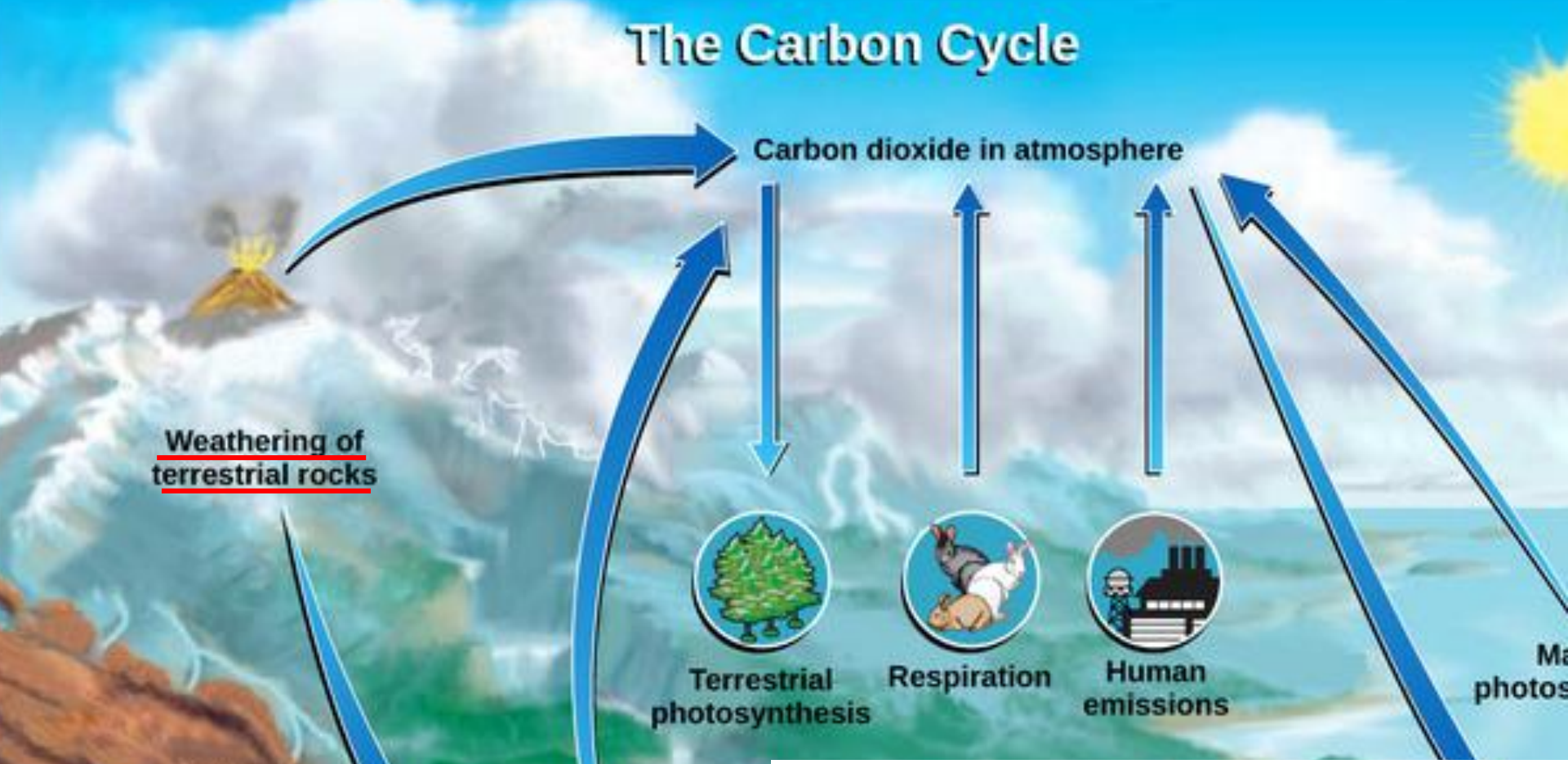
CO_2 low, cool, less rain

CO_2 high, warm, more rain



atmospheric CO_2 builds up

atmospheric CO_2 reduced



- Spodumene – $LiAlSi_2O_6$
- Pyroxenoid group
  - Wollastonite – $CaSiO_3$
  - Rhodonite – $MnSiO_3$
  - Pectolite – $NaCa_2(Si_3O_8)(OH)$

Sinks of CO_2

- Acid rain: $H_2O+CO_2 = H_2CO_3$
  - Contact with rock: weathering
- $CaSiO_3 + H_2CO_3 \rightarrow CaCO_3 + SiO_2$
  - Silicate rock → carbonate rock
  - carbonate rock = limestone

Chalk: isle of Whight

- CO_2 from the air locked up in chalk!
- Recycled via volcanoes

Earth – Venus - Mars

- On Earth: 170,000 times more CO_2 in carbonate rocks than in atmosphere
- Similarly for Mars
- What about Venus?

See BS p.139 for details!

Why so much CO_2 on Venus?

- Venus: 200,000 times more CO_2 than Earth
  - *Remember*: Earth 170,000 times more CO_2 in carbonate rocks
- Venus: no return to carbonate rocks
- Why?

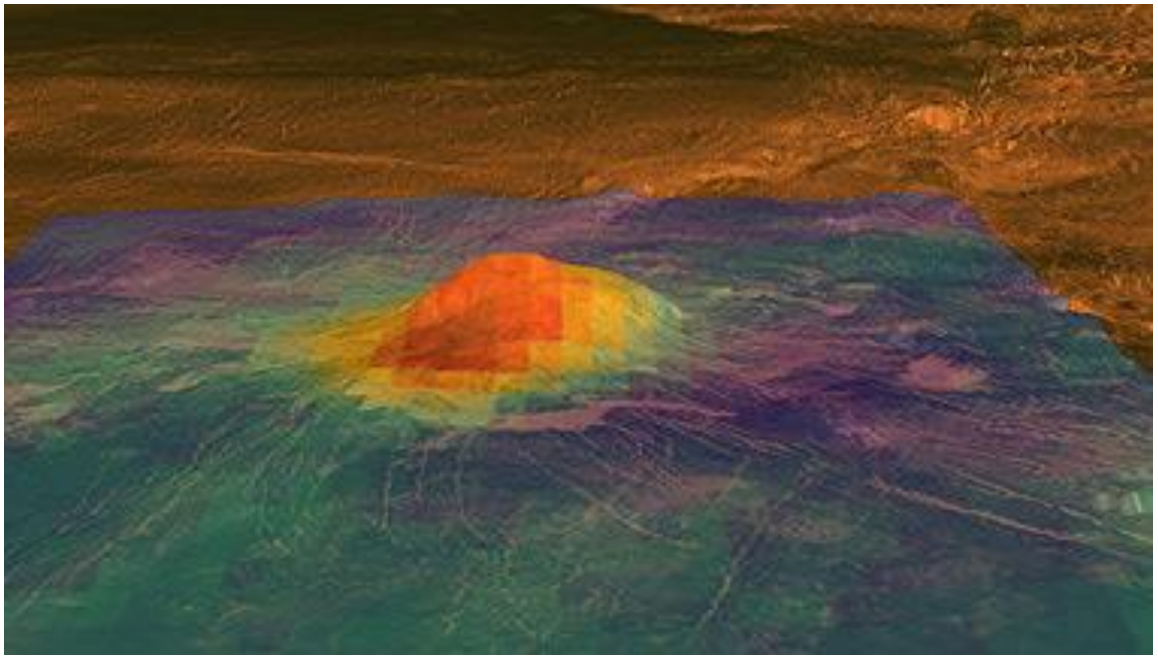
Why no CO_2 return into rocks on Venus?

- …
- ……
- ……….

into rocks

Why no CO_2 return on Venus?

- No water, no rain, no feedback
- Yet, volcanic activity



Idunn Mons
→ infrared
→ topography enlarged

0.25 Myr old

Why did Venus lose its water?

- Same reason as for Mars
- UV light: $H_2O \rightarrow H_2 + ½\ O_2$

  $\rightarrow$ photolysis
- H_2 lost through thermal escape
- Why?

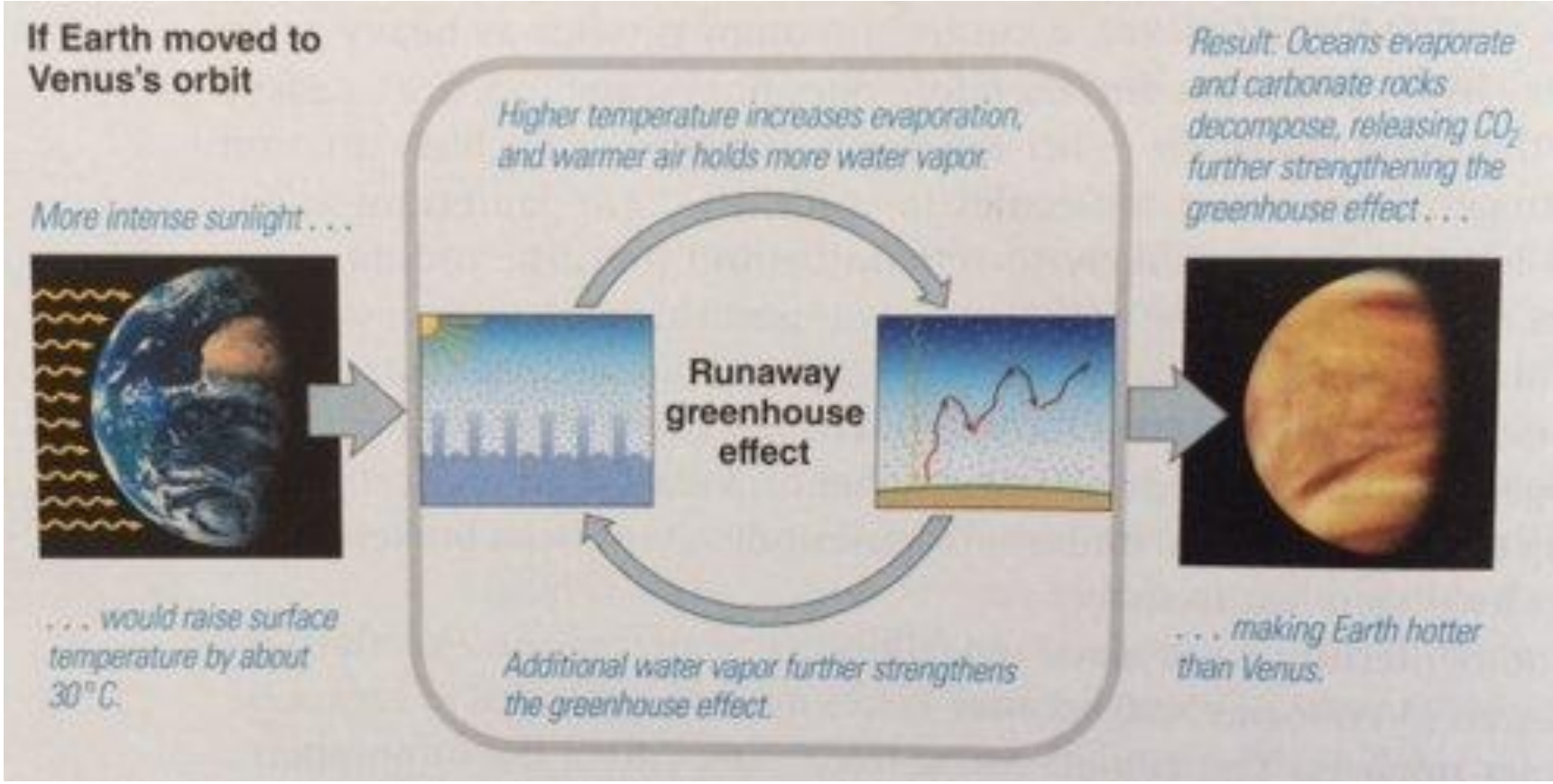
Thermal escape?

- Escape velocity?
  - Apollo 8 (Borman, Lowell, Anders)
- $\frac{1}{2}\, m v_e^2 = GMm/R$
  - $v_e = (2GM/R)^{1/2} = 11.2$ km/s
  - $\frac{1}{2}\, m v_H^2 = k_B T$
- H_2 is so light

Why not on Earth?

- Water vapor condenses to rain before too much gets lost
- Venus: unable to protect itself
- Too hot: H_2O also greenhouse gas
  - Hotter → more vapor → hotter still
- Runaway greenhouse effect

Runaway greenhouse effect



Earth has far less atmospheric CO_2 than Venus because

A. Earth was born with less gas
B. CO_2 was lost in giant impact
C. CO_2 is locked up in carbonate rocks

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If Earth had more greenhouse gases in its atmosphere, it would

A. Heat up

B. Cool off

C. Accelerate plate tectonics

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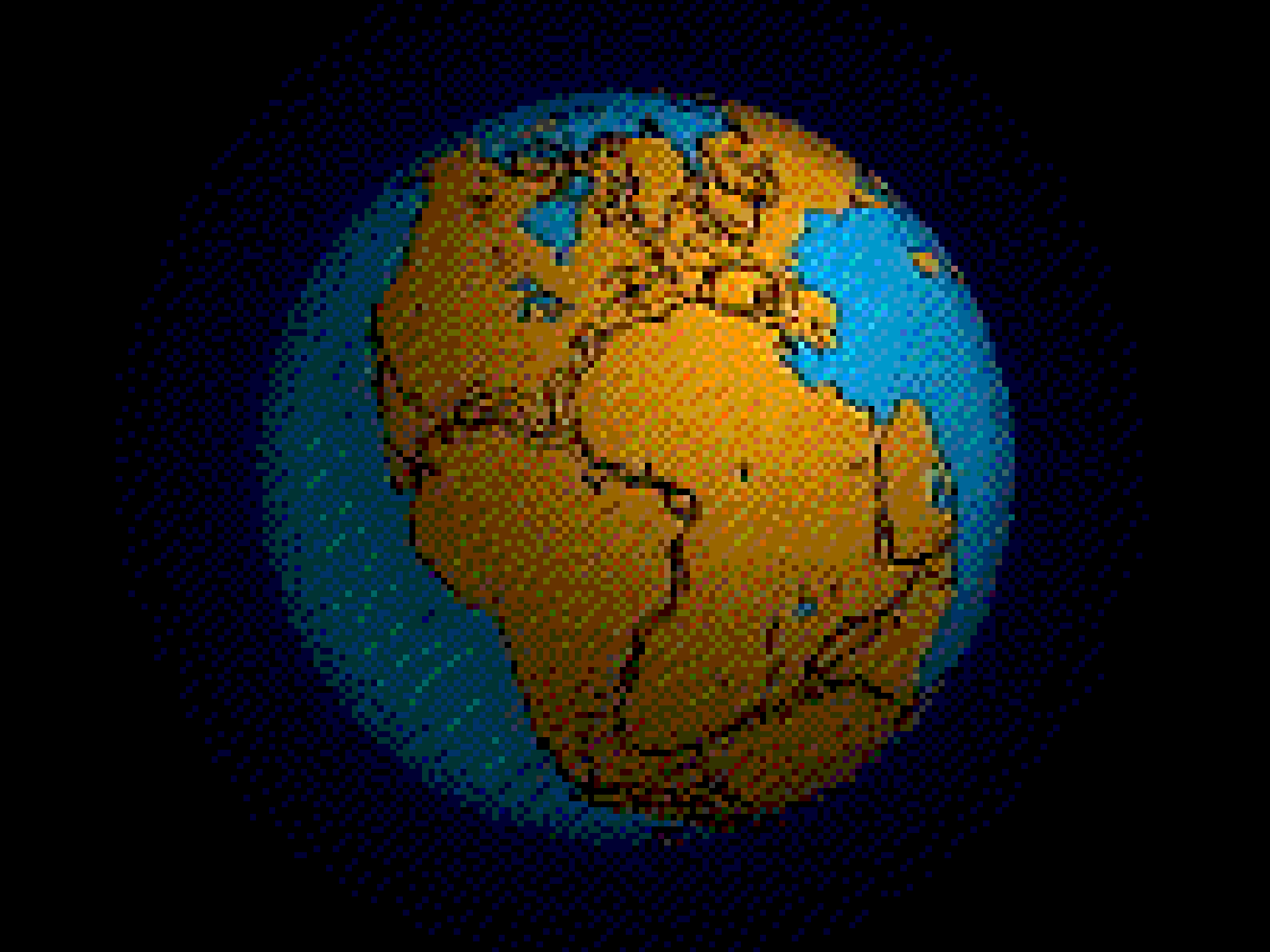
Earth's structure



Die Entstehung der Kontinente [1]).

Von Dr. **Alfred Wegener** (Marburg i. H.).

Mit 3 Textfiguren.

(Vortrag gehalten auf der Hauptversammlung zu Frankfurt a. M. am 6. I. 1912.)

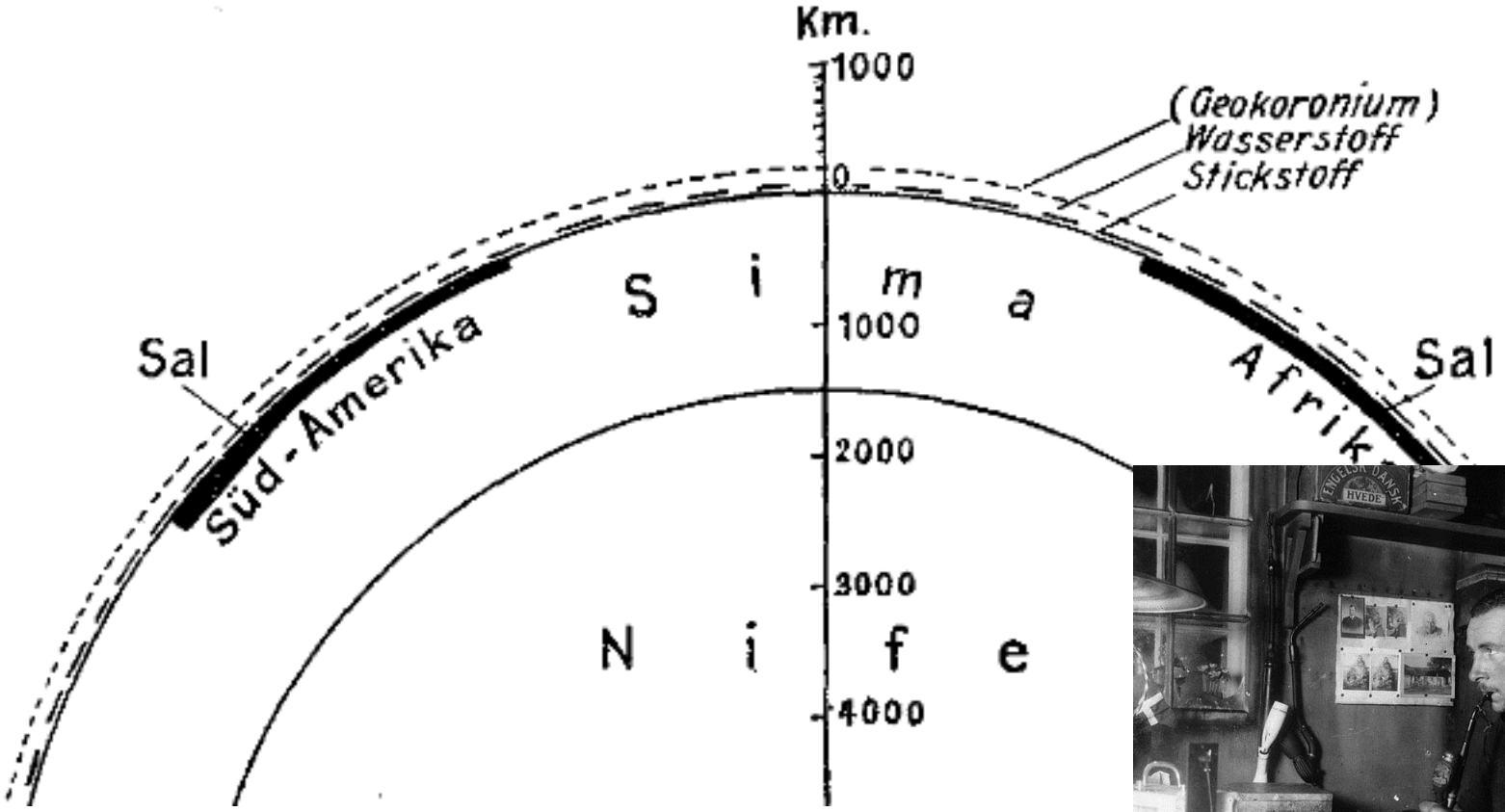
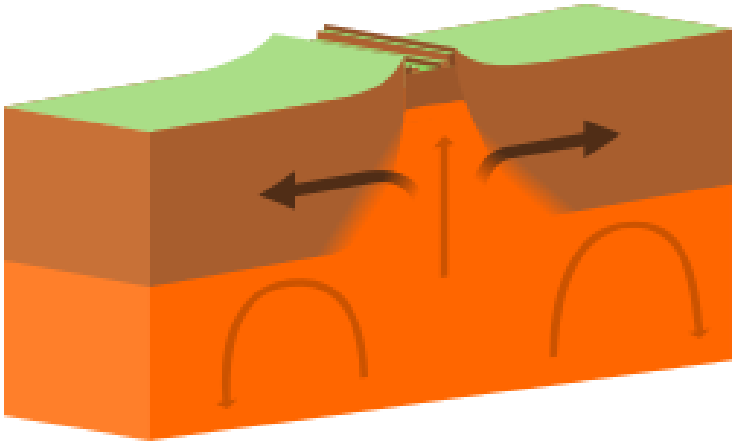
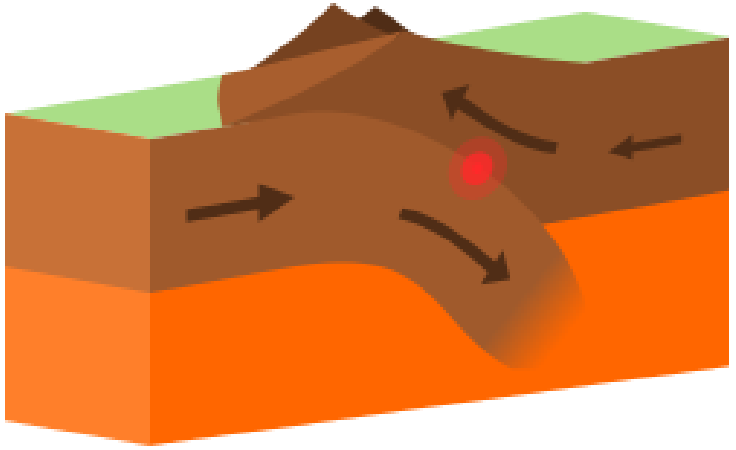
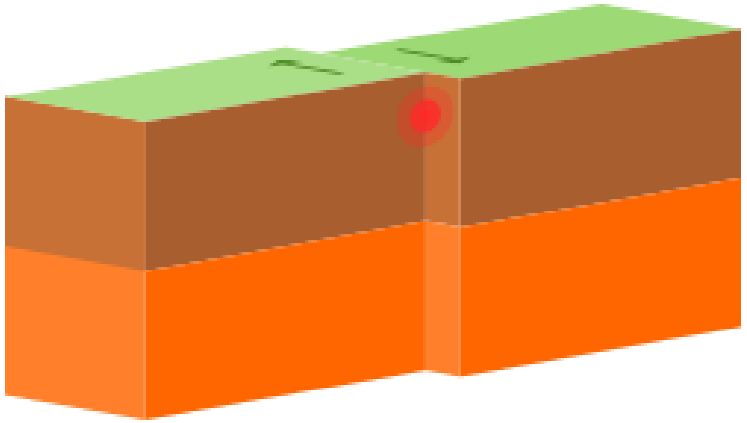


Plate tectonics

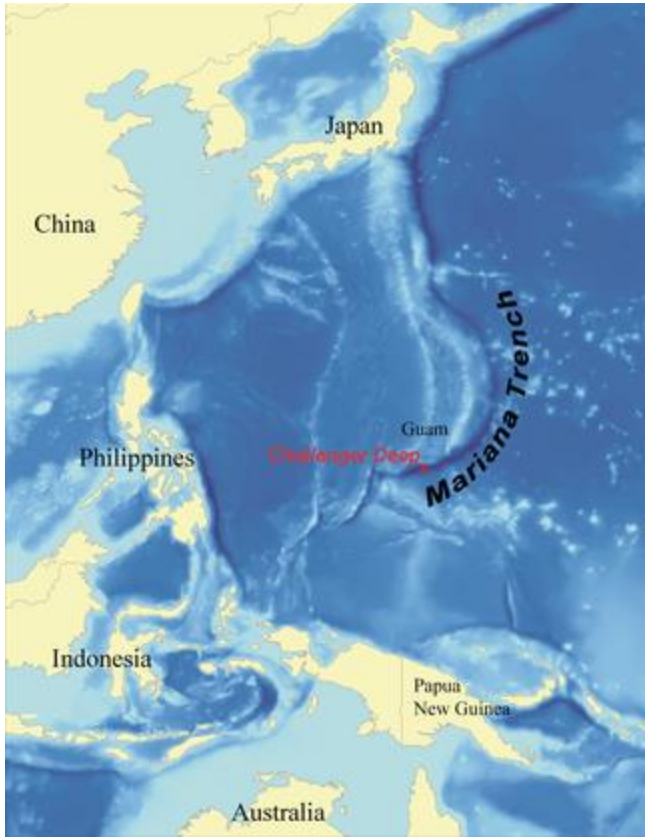




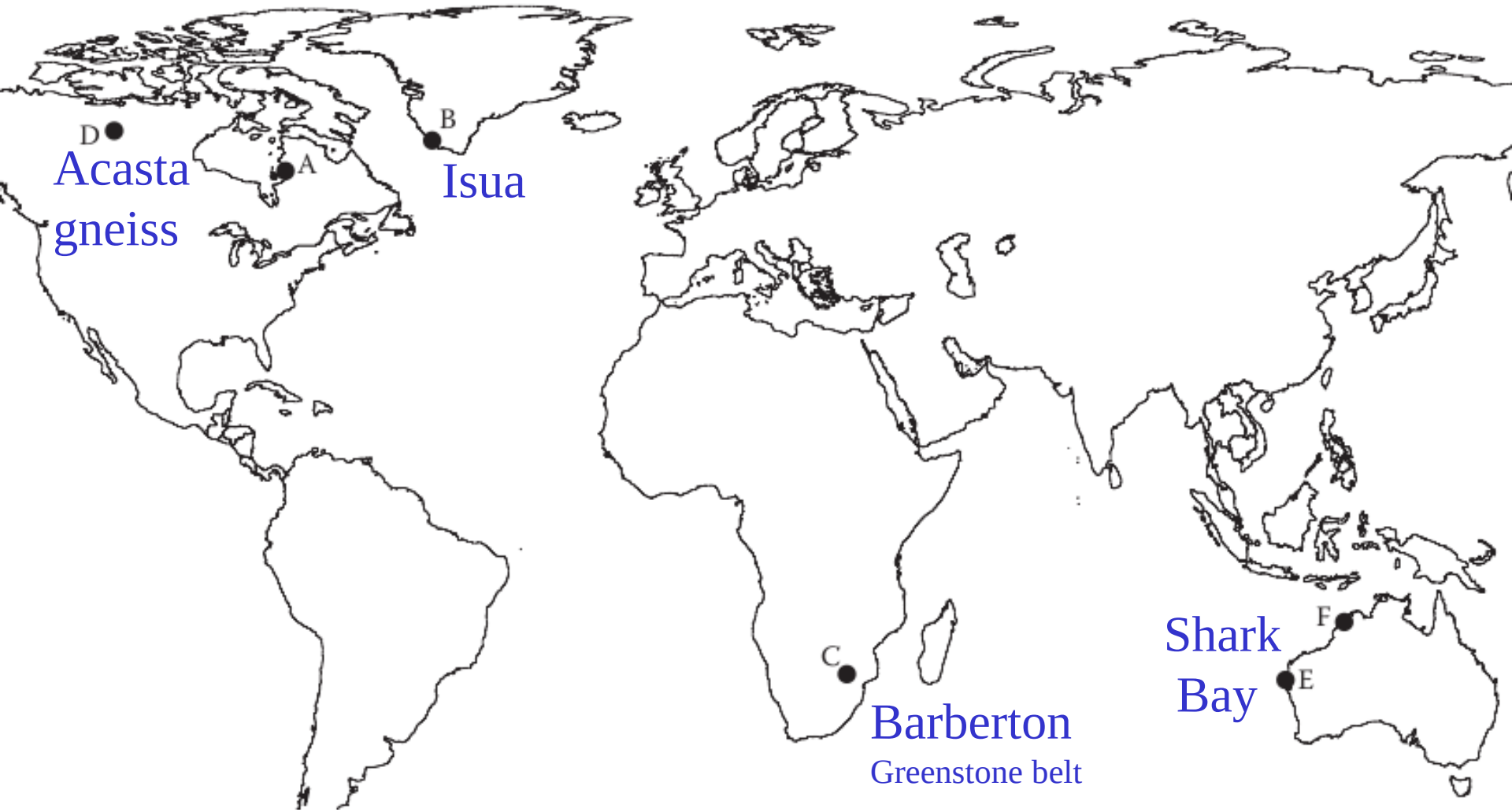


- Upwellings (heat)
- Subduction
- shear

Also deep in the pacific & atlantic



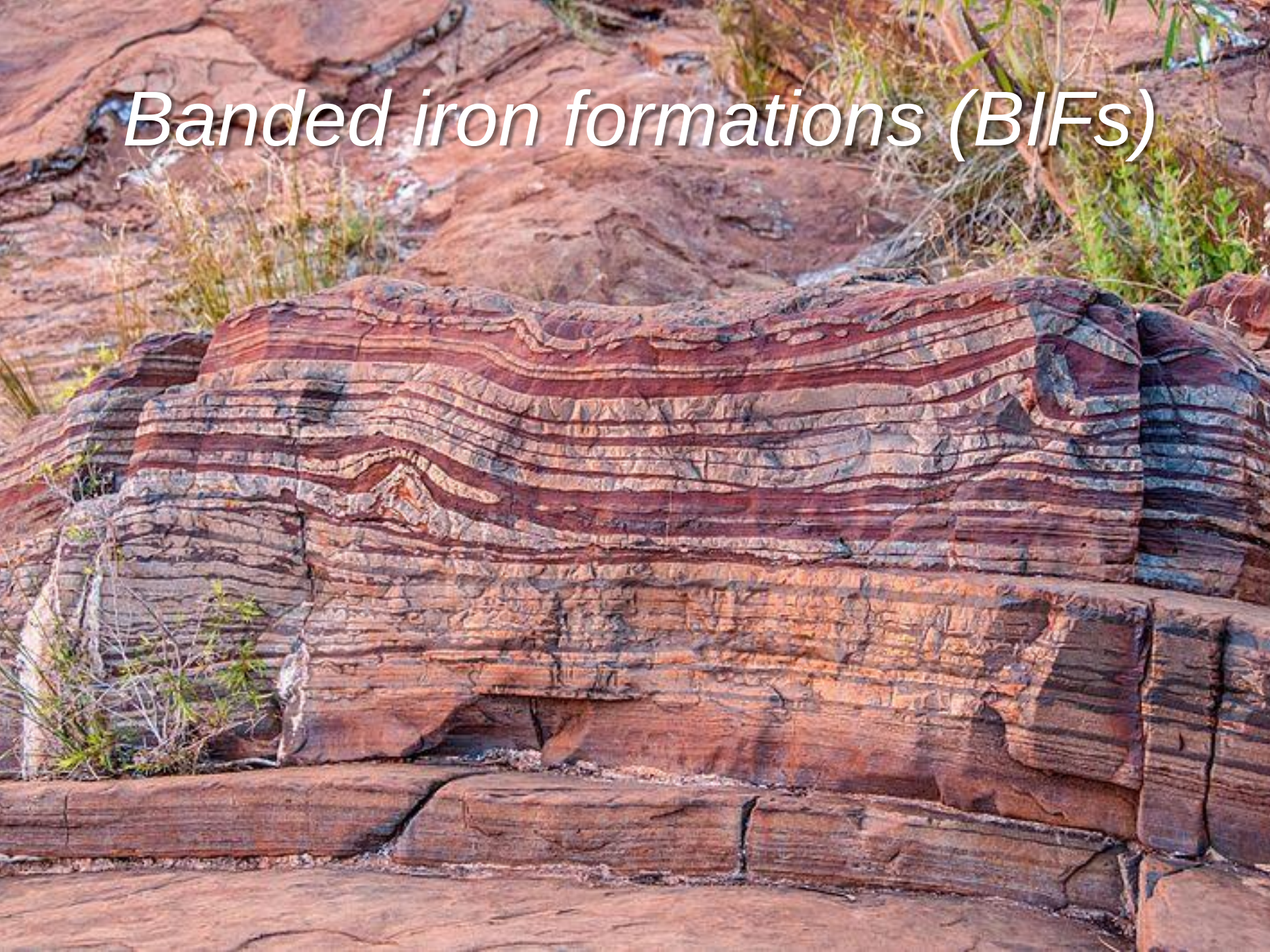
Rock locations



Long, p.211

Next week

- Banded iron formation (=rust)
- Evidence for early life on Earth
- Oceans 4.4 Gyr ago
- pp. 56 – 64 in RGS
  - After that
    - Significance of ^{13}C isotope
    - Cambrian explosion of life


Banded iron formations (BIFs)