



Lecture 13: The Atmosphere

1. (finishing up) Age of the Earth
2. The atmosphere
3. Planetary habitability
4. Mysterious water

We acknowledge and respect the $lək^wəŋən$ peoples on whose traditional territory the university stands and the Songhees, Esquimalt and W̱SÁNEĆ peoples whose historical relationships with the land continue to this day.



Age of the Earth

$\sim 4.6 \text{ Ga}$

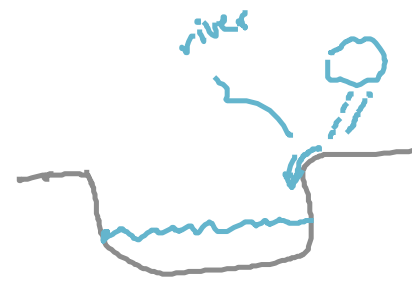
oldest ice \sim several million years

oldest mineral jack hills Australia $\sim 4.0 \text{ Ga}$

\rightarrow zircon

oldest rock $\sim 3.8 \text{ Ga}$

#1 historical attempts

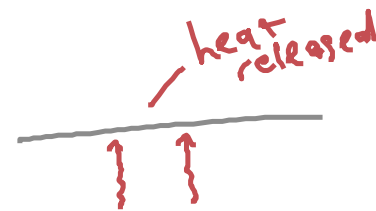


how long does it take to make the ocean salinity match observations?

\rightarrow way too young

\rightarrow ions become rocks over time

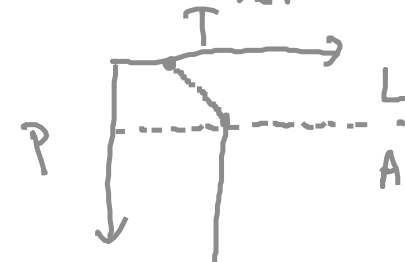
#2



• assumed Earth transports heat through conduction

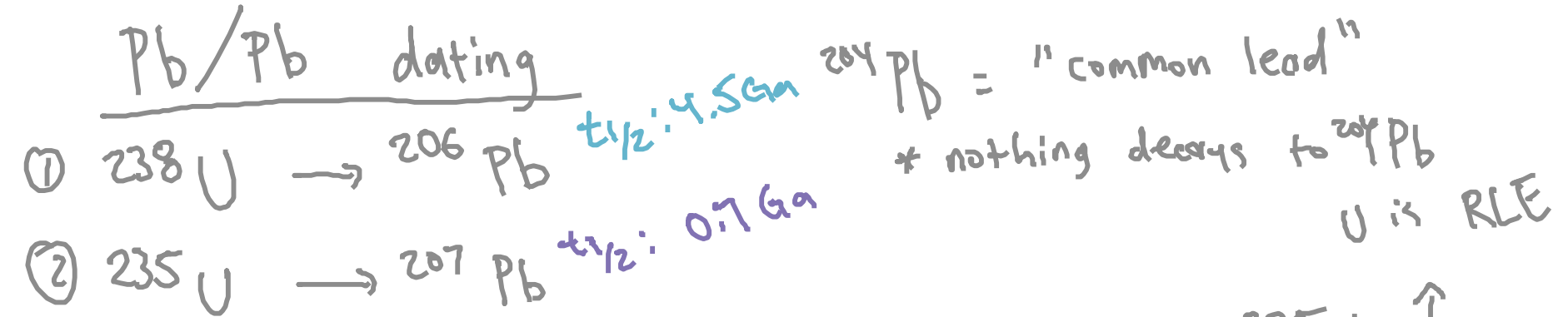
• predicted how long it takes Earth to cool to current

heat release measurements



Age of the Earth

Pb/Pb dating

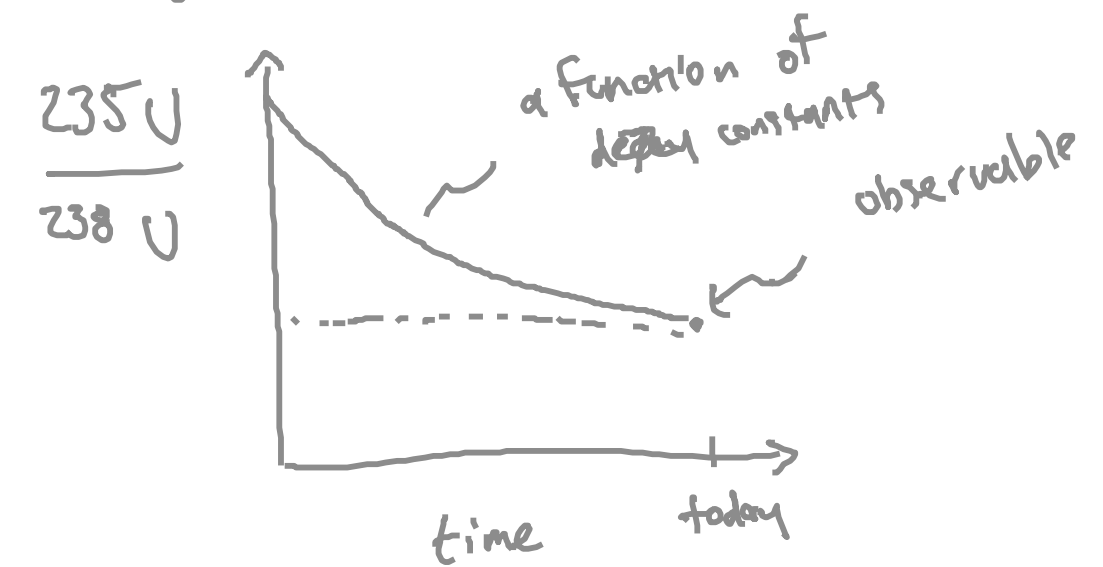


$$\textcircled{1} \quad \frac{^{206}\text{Pb}}{^{204}\text{Pb}} = \left(\frac{^{206}\text{Pb}}{^{204}\text{Pb}} \right)_0 + \frac{^{238}\text{U}}{^{204}\text{Pb}} \left(e^{\lambda^{238}t} - 1 \right)$$

initial

$$\textcircled{2} \quad \frac{^{207}\text{Pb}}{^{204}\text{Pb}} = \left(\frac{^{207}\text{Pb}}{^{204}\text{Pb}} \right)_0 + \frac{^{235}\text{U}}{^{204}\text{Pb}} \left(e^{\lambda^{235}t} - 1 \right)$$

Subtract



Age of the Earth

ratio of ② / ①

ratio of ① and ②

$$\frac{\frac{207\text{Pb}}{204\text{Pb}} - \left(\frac{207\text{Pb}}{204\text{Pb}}\right)_0}{\frac{206\text{Pb}}{204\text{Pb}} - \left(\frac{206\text{Pb}}{204\text{Pb}}\right)_0} = \frac{235\text{U}}{238\text{U}} \cdot \frac{(e^{\lambda_{235}t} - 1)}{(e^{\lambda_{238}t} - 1)}$$

rearrange into
 $y = mx + mC_1 + C_2$

$$y = \frac{207\text{Pb}}{204\text{Pb}}$$

$$x = \frac{206\text{Pb}}{204\text{Pb}}$$

$$m = \frac{235\text{U}}{238\text{U}} \cdot \frac{(e^{\lambda_{235}t} - 1)}{(e^{\lambda_{238}t} - 1)}$$

... same algebra

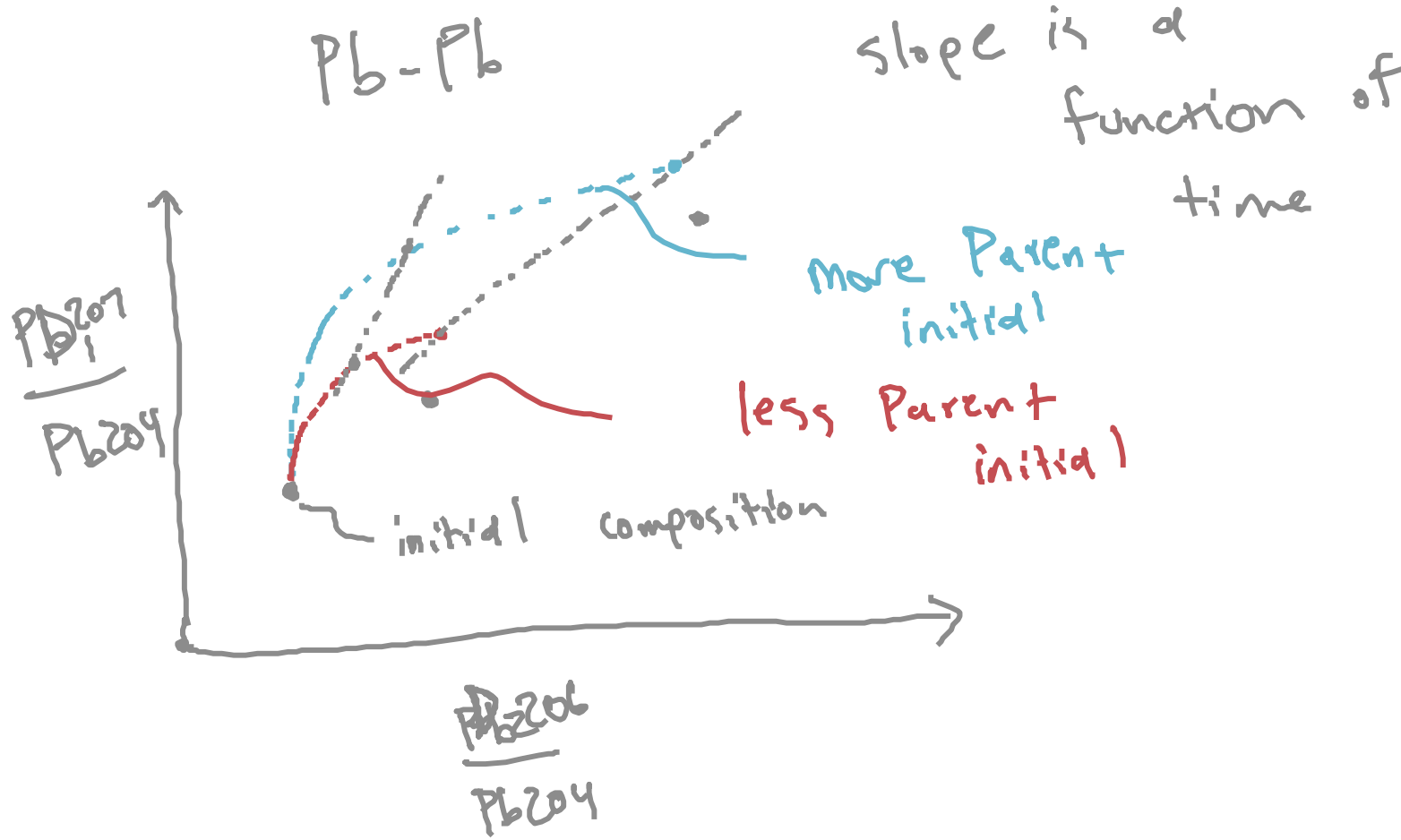
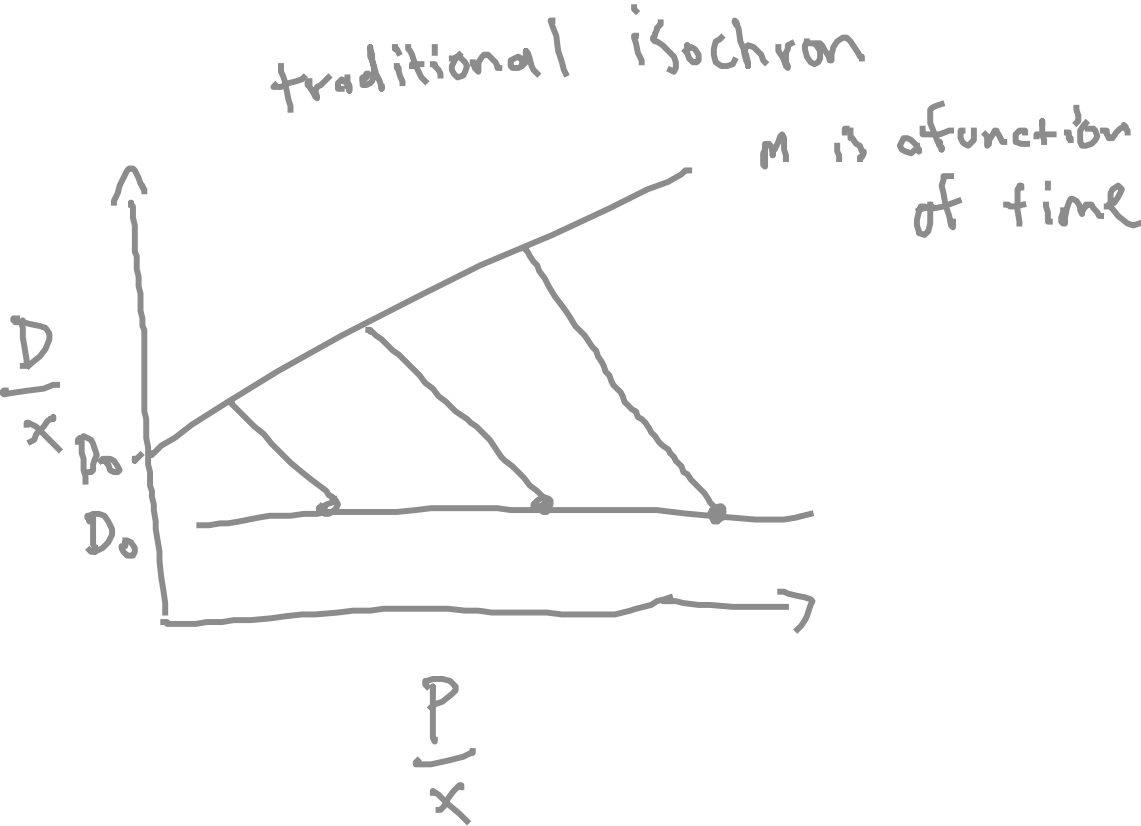
$$\frac{207\text{Pb}}{204\text{Pb}} = \frac{235\text{U}}{238\text{U}} \cdot \frac{(e^{\lambda_{235}t} - 1)}{(e^{\lambda_{238}t} - 1)} \cdot \frac{206\text{Pb}}{204\text{Pb}} + \left(\frac{207\text{Pb}}{204\text{Pb}}\right)_0$$

$$y = mx + b$$

$$b = mC_1 + C_2$$



Age of the Earth



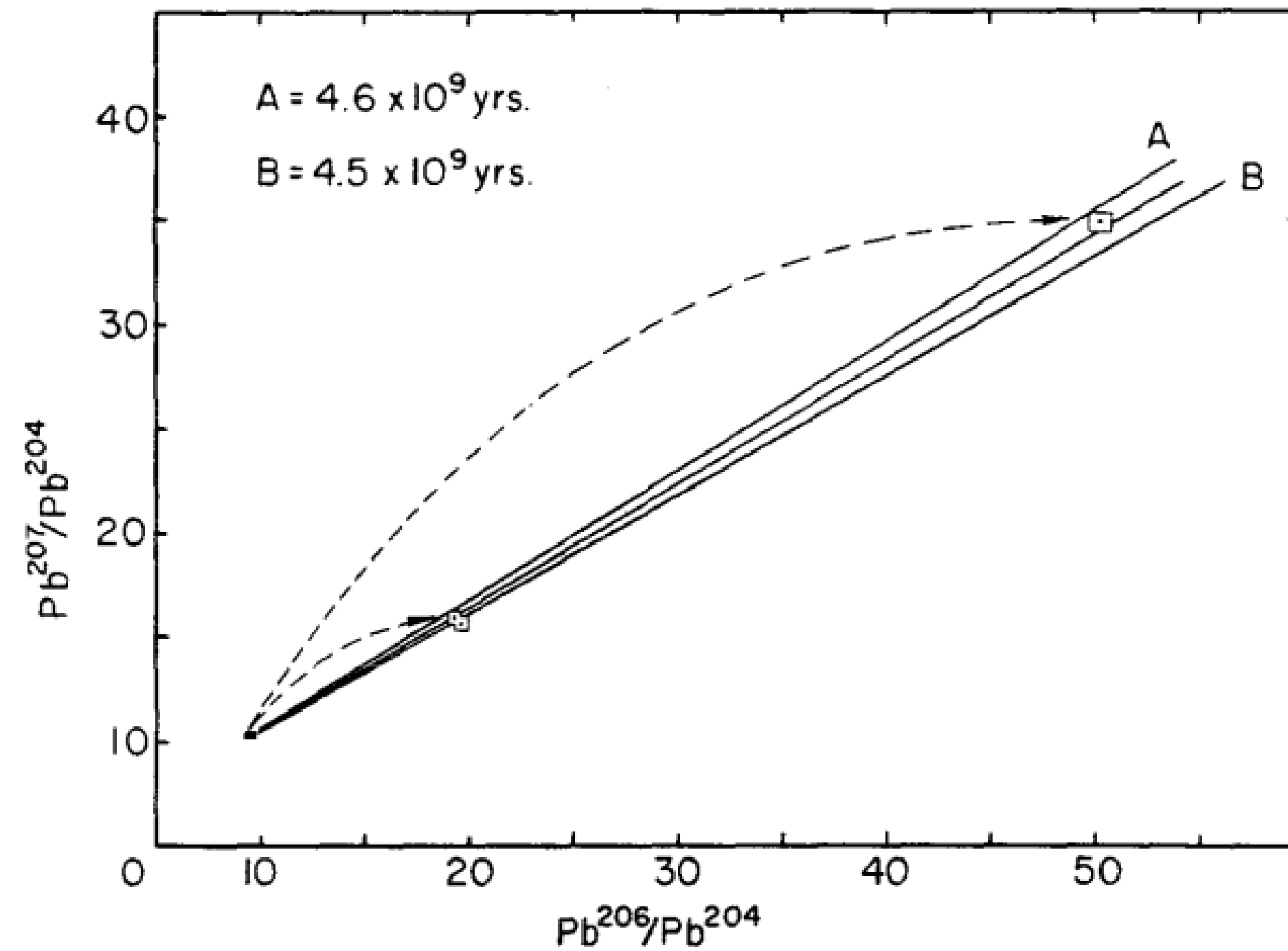
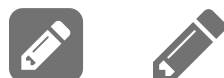
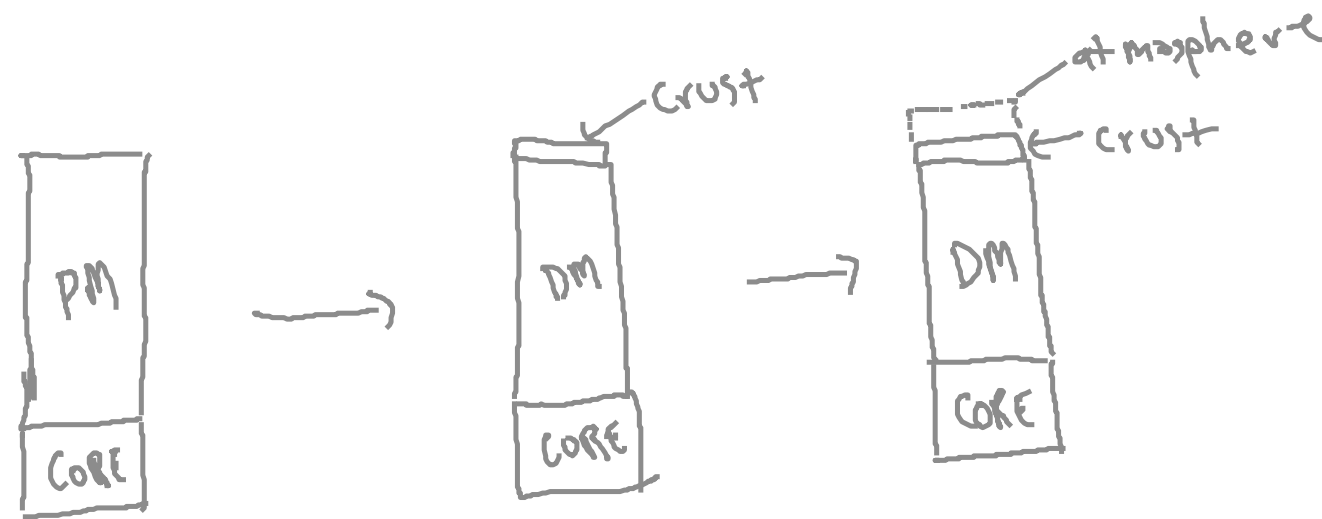


Fig. 1. The lead isochron for meteorites and its estimated limits. The outline around each point indicates measurement error.

Age of meteorites and the earth. Claire Patterson 1956



The atmosphere



What is the atmosphere (physically)?



What is the atmosphere chemical composition?

78% Nitrogen

21% Oxygen

0.9% Argon

0.04% CO_2 (400ppm)

~1% water vapor at sea level

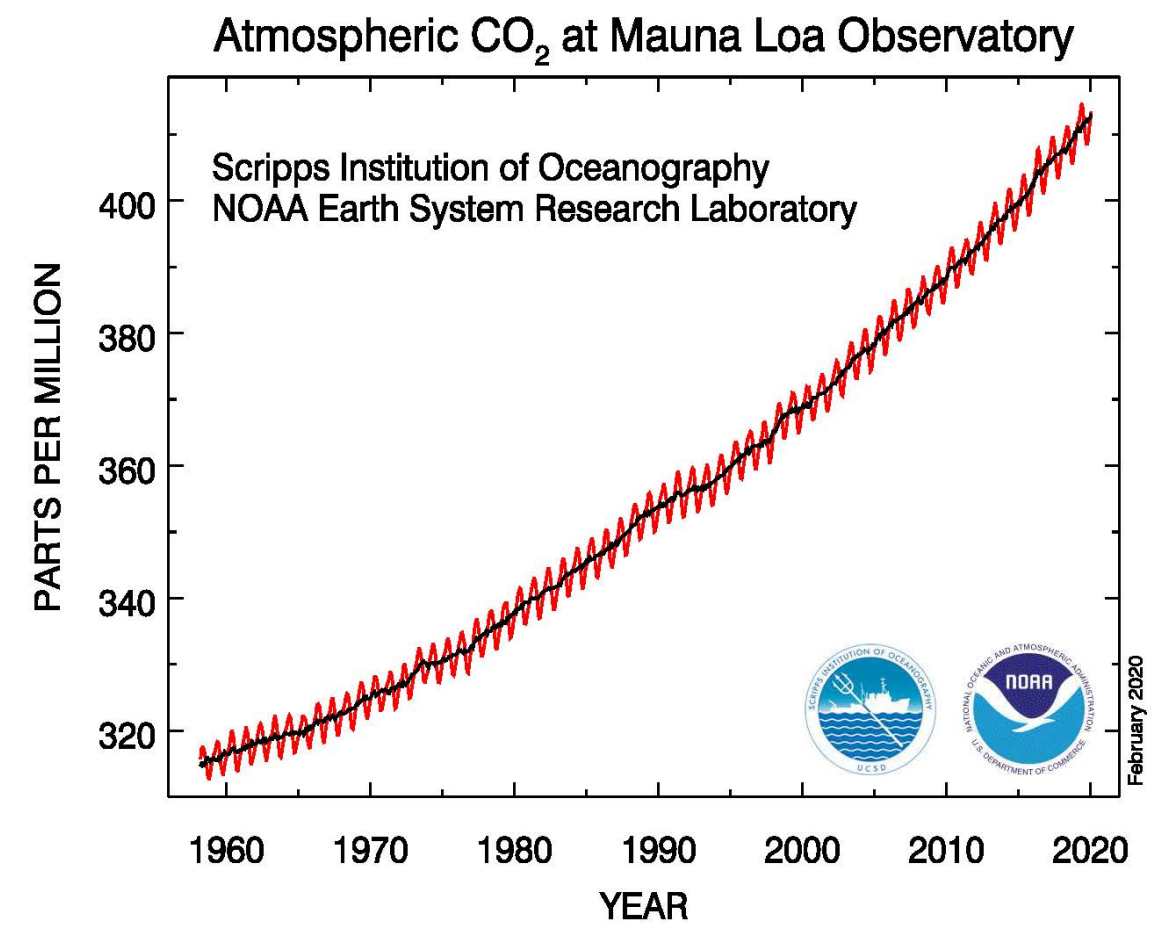
↳ temp dependant

GOE:

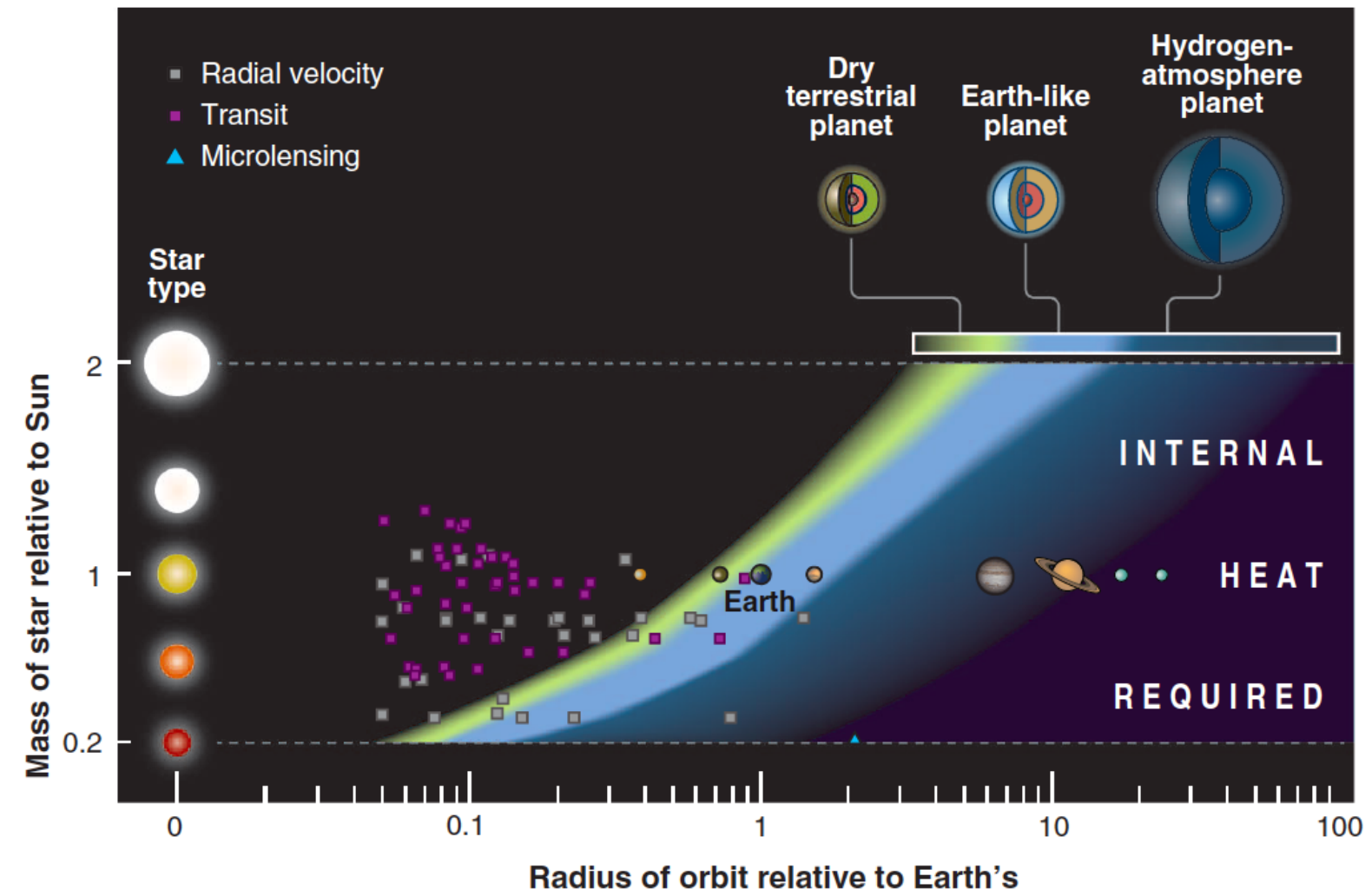
Great Oxygenation
Event ~ 2.5 Ga

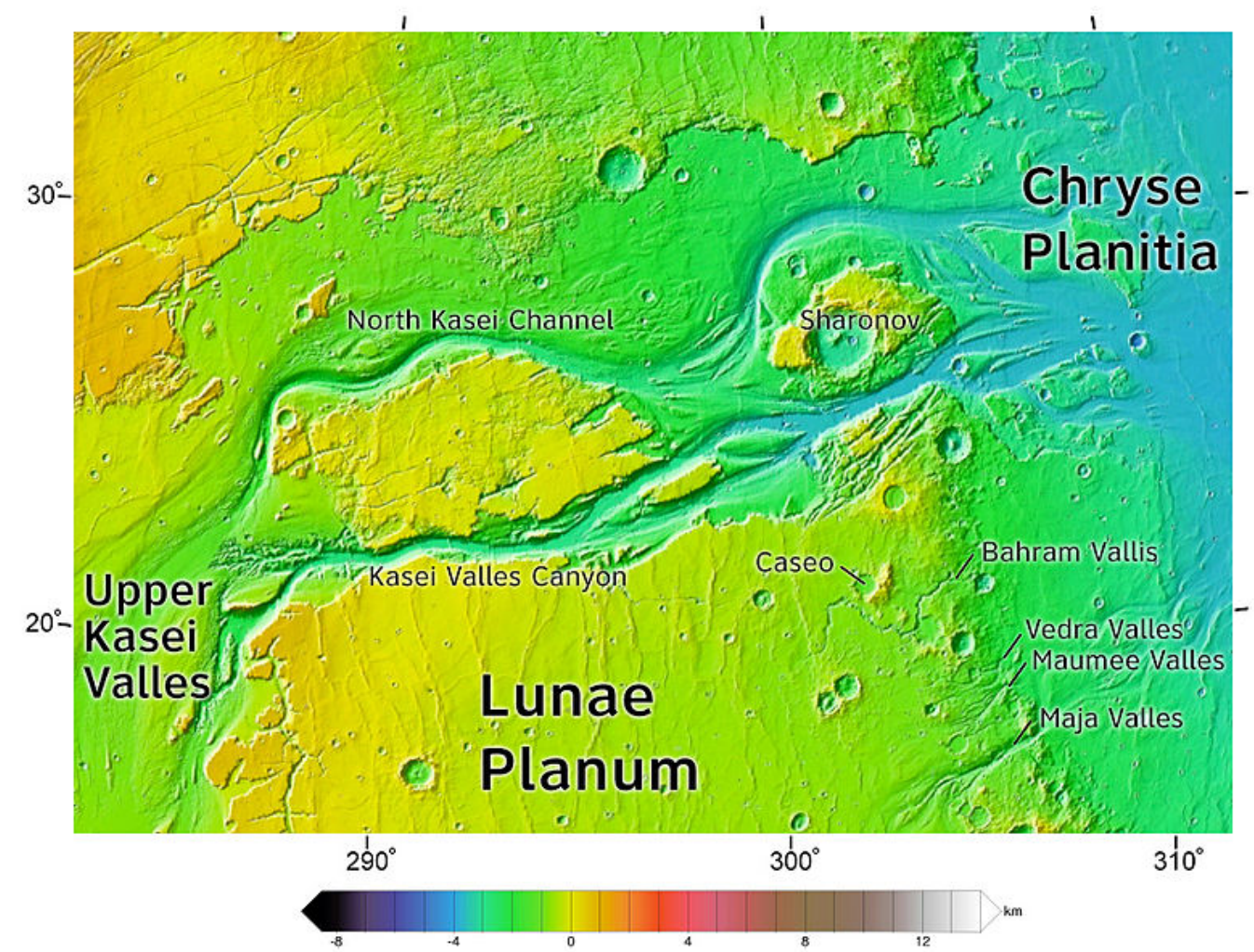
70.01%





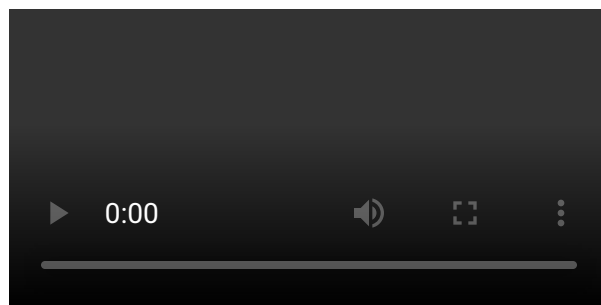






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In [3]: Video("videos/planet_formation.mp4")
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Out[3]:



Where does our water come from?

① Started with it

└ during accretion major heating which releases
volatiles

② Late heavy bombardment
└ collected "late"

— many impactors from 4.5 to 4.0
Ga

③ Captured from comets

