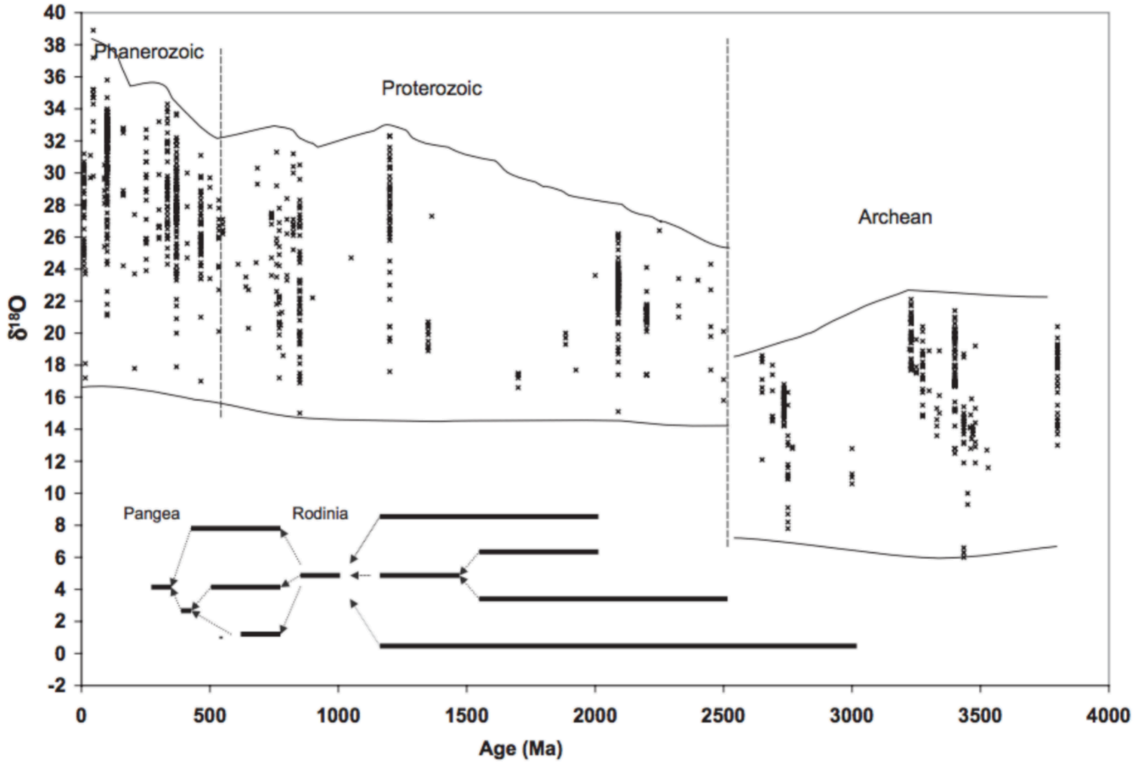
**GEOS 32060 – Spring 2019 – Homework 1**

Due in my mailbox (HGS building, 1st floor) Friday 19 April 4pm. No credit will be given for answers without working. It is OK to use e.g. Mathematica, but if you do, please print out the work.

**Q1. The integrity of the ancient O-isotope record.**

In class we discussed the C-isotope record ($^{13}C/^{12}C$); the record of infrequent, but sometimes severe, glaciations; and the record of changing partial pressure of atmospheric oxygen ($pO_2$) over geologic time. Now we will look at one candidate paleo-temperature proxy, including its limitations: the O-isotope ($^{18}O/^{16}O$) record.

The following figure is from Knauth (2005, Palaeogeography Palaeoclimatology Palaeoecology); see also Knauth & Lowe (GSA Bulletin, 2003). The horizontal bars at the bottom show supercontinent breakup and dispersal (not needed to answer the question). "Delta notation" refers to parts-per-thousand enrichment relative to a standard. The data are for chert.




Assume that formation temperature of chert is given by

$$1000 \ln \alpha \text{ chert–}H_2O = 3.09 \times 10^6 T^{-2} - 3.29,$$

where

$$\alpha = \frac{1000 + \delta^{18}\text{O chert}}{1000 + \delta^{18}\text{O } H_2O}$$

and $T$ = temperature in °K.

Assume the oxygen isotope composition of seawater has been constant over time and is zero on the del-18-O scale. What is the sign and magnitude of Earth temperature change since 3.5 Ga recorded by chert?

(b) Assume that burial and exhumation is a random walk with step size 250m and step length 50 Myr. What is the typical peak burial depth of sediments initially at the seafloor, and now exposed at the surface, that are 500 Myr in age? What about 3 Gyr in age? (Remember that sediments cannot have a negative burial depth; this corresponds to sediment erosion and loss of the record).

(c) If geothermal heat flow is 0.1 W/m2 , thermal conductivity is 2 W/m/K , and sediment oxygen-isotope composition is reset to the temperatures at peak burial depth, what would be the typical percentage correction to your answer to part (a)? Hint: Use Fourier's law of heat conduction.

(d) Does the model assumed in part (b) provide a good explanation for the scatter in the figure (i.e. the vertical width of the "envelope" of data points)? Why or why not?

**Q2. Greenhouse effect + elementary models of radiation balance.**

Venus surface temperature is ~750K, Mars surface temperature is ~210K.
(a)Draw the brightness temperature versus wavelength for Venus and Mars if they both radiated to space as a black-body at their observed surface temperatures (no atmosphere on either planet). (1/5 of credit)

(b)Below is brightness temperature versus wavelength for Venus and Mars. Why is the average brightness temperature for Venus and Mars similar? Explain in detail. (3/5 of credit)

(c) Suppose that the brightness temperature of Venus was slightly less at all infrared wavelengths than that of Mars. How might this be true, given that Venus is closer to the Sun? (1/5 of credit)

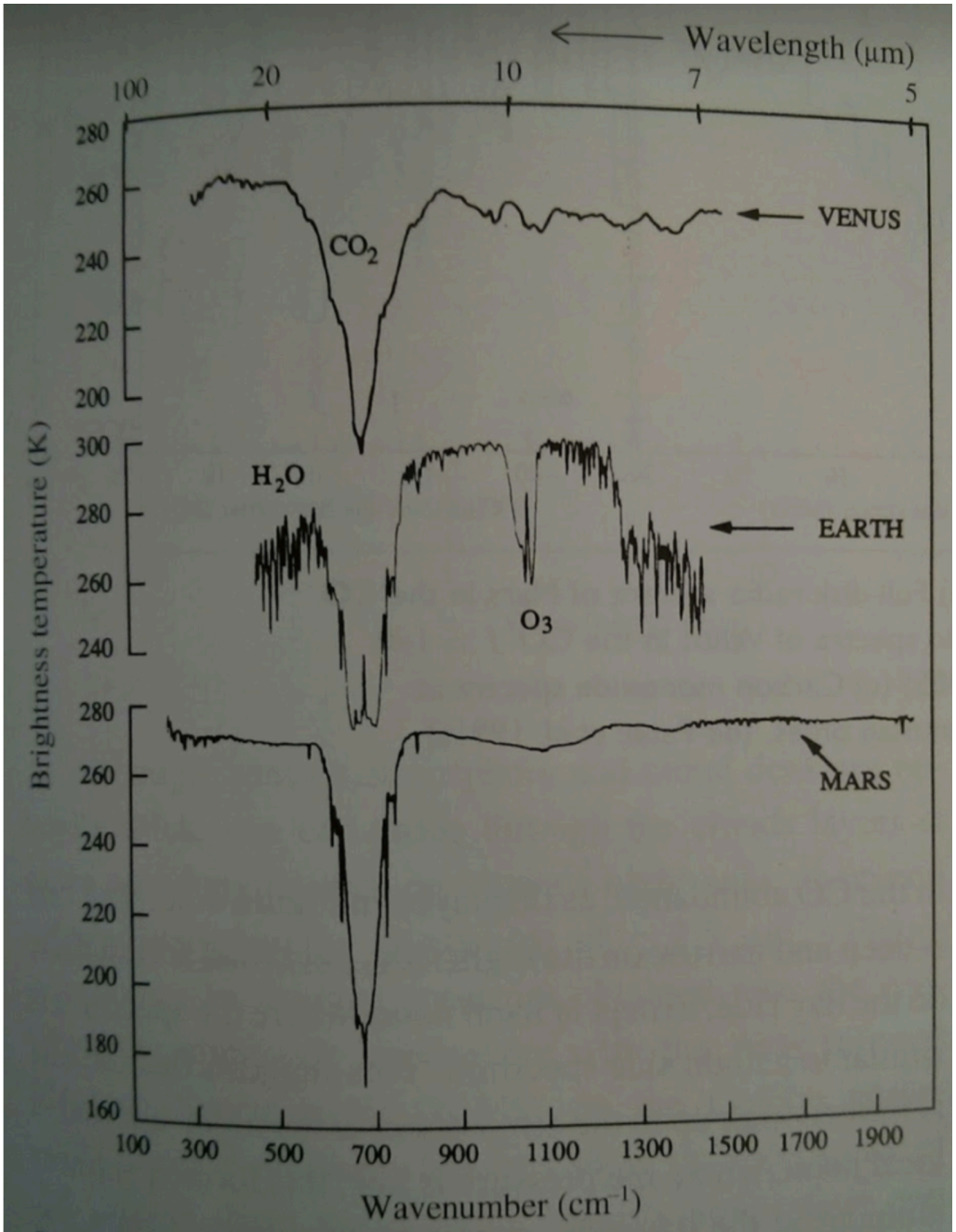



FIGURE 4.6 Thermal infrared emission spectra of Venus, Earth and Mars. The Venus spectrum was recorded by Venera 15, the spectrum of the Earth by Nimbus 4 and that of Mars by Mariner 9. (Adapted from Hanel *et al.* 1992)

*from de Pater & Lissauer 2001*