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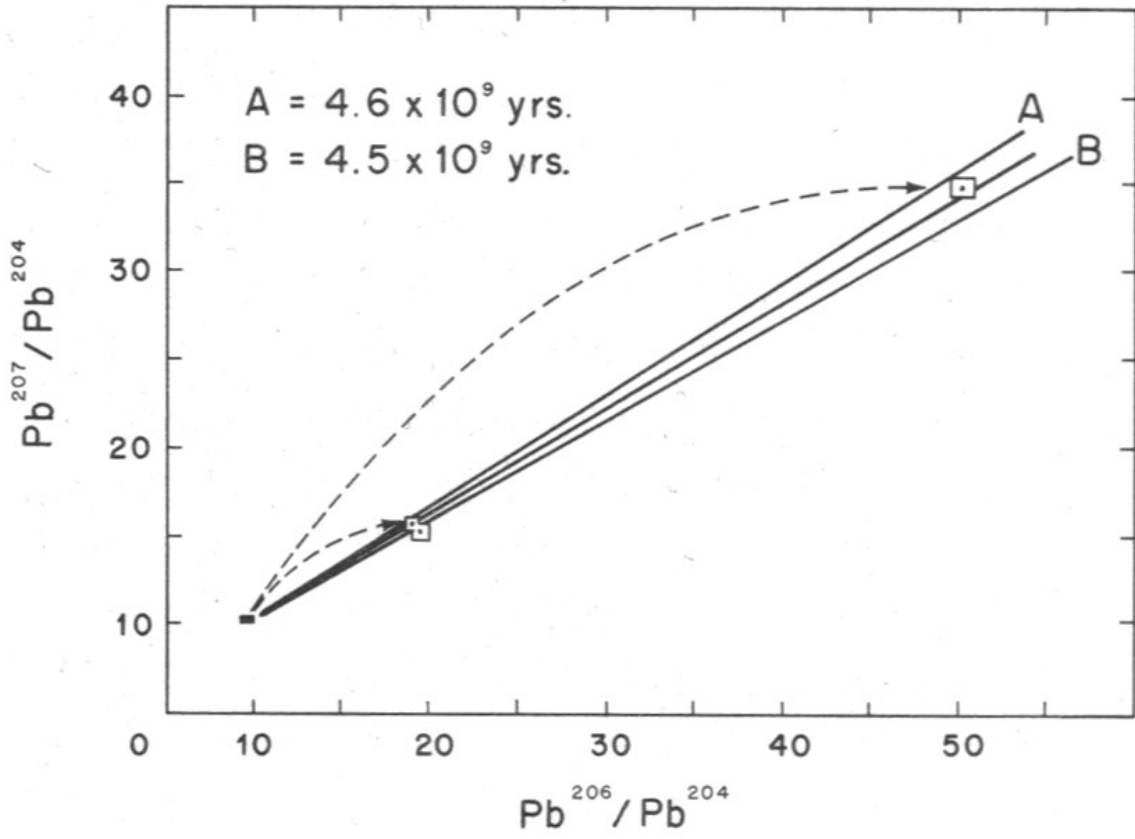
12.002 Physics and Chemistry of the Earth and Terrestrial Planets  
Fall 2008

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**12.002 Physics and Chemistry of the Terrestrial Planets**  
**Fall 2008**  
**Professors Leigh Royden and Benjamin Weiss**

**Problem Set #1: Geochronology and the Age of the Solar System**  
due Friday Sep 26 in class

1. Read the classic 1956 paper: Patterson, C., Age of meteorites and the Earth, *Geochim. Cosmochim. Acta*, 10, 230-237, 1956. This presents the first definitive radiometric age of the Earth and solar system.
  - (a) Starting with the rate expressions for radioactive decay of  $^{238}\text{U}$  and  $^{235}\text{U}$ , derive Patterson's equation (1) on page 231. What do you need to assume about the age and initial lead content of the two meteorites?
  - (b) If the solar system were now 6 B.y. old rather than 4.5 B.y. old, would the slope of the isochron be shallower or steeper than that in Patterson's Fig. 1? What if the solar system were now 3 B.y. old?
  - (c) On Patterson's Fig. 1 (attached), roughly sketch how the isochron of the meteorites would have appeared to a hypothetical observer about a billion years ago when the meteorite was only about three and a half billion years old. Is the isochron steeper or shallower than the present-day isochron? Reconcile this with your answer to (b) using the isochron equation for Pb/Pb dating.
  - (d) The data for the Canyon Diablo meteorite were collected by measuring the Pb isotopic composition in the mineral troilite. What is the chemical formula of this mineral? Would you expect to find more Pb or U in troilite? How does this help us to constrain the initial Pb isotopic composition of the Earth?
  - (e) Use the data in Patterson's Table 1 to determine the age of the solar system. Do this by recreating his Figure 1: plot the Pb isotopic composition of the five meteorites and determine the slope of the best fit line that passes through the Canyon Diablo meteorite. Note that because equation (1) is transcendental, you will need to calculate its right side iteratively in order to solve for time.
  - (f) Based on these results, what is the minimum age for the formation of the crust of asteroid 4 Vesta? What is the minimum age for the formation of the core of the asteroid that produced Meteor Crater in Arizona?
  - (g) Now, going beyond Patterson to results from the modern era, what is the name of given to the oldest known solar system solids? What is their precise age (to within 1 million years)? Give a first order explanation for their composition based on the expected condensation sequence for the solar nebula.



Patterson's Figure 1 for Problem 1c.