EPS 122: Physics of the Earth and Planetary Interiors

Problem Set 5: Geochronology and heat

1) Four mineral samples from a meteorite have neodymium and samarium-neodynium isotope ratios as follows

$^{143}Nd/^{144}Nd$	$^{147}Sm/^{144}Nd$
0.5105	0.12
0.5122	0.18
0.5141	0.24
0.5153	0.28

a) Find the age of the meteorite
b) Find the initial $^{143}Nd/^{144}Nd$ ratio for this meteorite
c) Discuss the relevance of the initial $^{143}Nd/^{144}Nd$ ratio of meteorites

2) Calculate an equilibrium geotherm from the one-dimensional heat-flow equation given the following boundary conditions:

$\partial T/\partial z = 30$ °C km^{-1} at z = 0 km and
T = 700 °C at z = 35 km

Assume that the internal heat generation is 1 μWm^{-3} and the thermal conductivity is 3 W m^{-1} °C^{-1}.

3) On missions to Venus the surface temperature was measured to be 740K, and at three sites heat-producing elements were measured (in percentage of total volume) as follows (ppm is parts per million).

	Venera 8	Venera 9	Venera 10
K (%)	0.47	0.30	4.0
U (ppm)	0.60	0.46	2.2
Th (ppm)	3.65	0.70	6.5

The density of the Venusian crust can be taken to be 2.8 x 103 kg m^{-3}.

a) Calculate the heat generation at each site.
b) Using the one one-dimensional equilibrium heat-conduction equation, calculate and plot the three Venus geotherms (Aphroditotherms) down to 50 km depth at each site. Assume that the conductivity is 2.5 W m^{-1} °C^{-1}, and at a depth of 50 km the heat flow from the mantle and deep lithosphere of Venus is 21 x 10^{-3} Wm^{-2}.
c) What do these Aphroditotherms suggest about the internal structure of the planet?

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4) Volcanic flood basalts can be several kilometers thick and extend over very large areas. A 2 km thick basalt is erupted at 1200 °C. If the solidus temperature is 900 °C, estimate the time required for the basalt to solidify.

5a) Calculate the difference in depth of the seabed at the intersection of a mid-ocean ridge and transform fault. Assume that the ridge is spreading at 5 cm yr^{-1} and that the ridge axis is offset 200 km by the transform fault.
b) Calculate the difference in depth on either side of the same fault 1000 km from the ridge axis and 3000 km from the ridge axis.