EART160 Homework #3 Due Friday 30th Jan 2009

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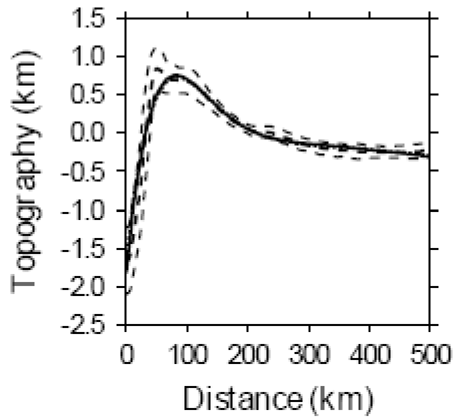


1. The figure above shows a topographic profile across part of a *corona* (a circular feature with a trench surrounding it) on Venus. We are going to interpret the trench and rise as a flexural feature due to loading.

a) Mark on the figure the approximate distance over which flexure is deforming the lithosphere [1]

b) Assuming that this distance is the flexural parameter, use the expression given in your notes to determine the *elastic thickness* of the lithosphere on Venus. You may assume that g=9 ms-2, ν=0.3, the density contrast is 500 kg m^{-3} and E=100 GPa [3].

c) How does the elastic thickness on Venus compare with that of continents on Earth? Why might this be a surprising result? [2]

d) The base of the elastic layer is determined by a temperature of about 1000 K and the surface temperature of Venus is 700 K. What is the thermal gradient on Venus? [1]

e) Thermal gradients on Earth are about 25 K/km. What does this result imply about the relative rates at which the Earth and Venus are cooling down? [2]

f) How might you explain this difference in cooling rates? [1] [10 total]

2. Here we're going to consider volcanism on Io.

a) The velocity u of magma traveling upwards through a dike of width w is given by

$$u = \frac{w^2 g \Delta\rho}{\eta}$$

where g is gravity, $\Delta\rho$ is the density contrast between magma and the surrounding rock, and η is the viscosity. Examine the effect of each variable in turn and explain why this equation makes physical sense [4].

b) If the total height of the dike is d, write down an expression for the time taken for a packet of magma to get from the bottom to the top of the dike [1]

c) Also write down an expression for how long it takes the material in the dike to cool by conduction [1].

d) By comparing the expressions for the cooling time and the transit time, derive an expression for the minimum width of a dike which will allow magma to ascend all the way to the surface [3]

e) On Io, let's assume that we have d=20 km, $\Delta\rho$=100 kg m-3, g=1.8 ms^{-2}, κ=10^{-6} m^{2}s^{-1} and η =10^3 Pa s. Using this information, what is the minimum dike width? [1]

f) If the total horizontal length of the dikes on Io is L and they all have a constant width w, write down an expression for the magma discharge rate (in m^{3}s^{-1}) from these dikes in terms of u, L and w [1]

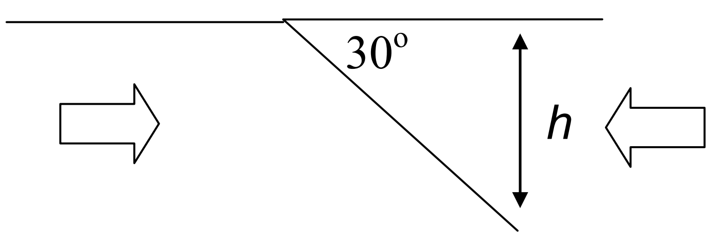
g) The magmatic resurfacing rate on Io is about 1 cm/yr. If the radius of Io is 1800km, what is the corresponding magma discharge rate (in m^{3}s^{-1})? [2]

h) If dikes on Io are 1m wide, use the information given above to determine what the total length of dikes L has to be in order to produce the observed resurfacing rate [4]

i) How easy would it be to spot these dikes from a spacecraft? [1] [18 total]

3 Here we're going to consider compressive stresses on Mercury.

a) The figure below shows a fault dipping at 30^o and extending to depth h. Write down an expression for the vertical (lithostatic) stress on the bottom of the fault. The crustal density is ρ and the gravity is g. [1]



b) Write down an expression for the stress acting perpendicular to the fault plane [1]

c) Using Byerlee's law, write down an expression for the tectonic shear stress required to make this fault move. The coefficient of friction is f. [1]

d) Let's assume that Mercury has cooled, on average, 20 K over its history. If the coefficient of thermal expansion is 3×10^{-5} K^{-1} and Young's modulus is 100 GPa, how much tectonic stress is generated by Mercury cooling and contracting? [2]

e) Use the results obtained above to deduce the maximum depth of a fault which moves in response to Mercury's cooling stresses. Assume f=0.6, ρ=3000 kg m^{-3} and g=3.7 ms^{-2}. How does this depth compare with faults on Earth? [3]

f) If the faults are separated on average by 100 km, how much movement along the fault plane does there have to be to accommodate the strain caused by Mercury cooling? [2]
[10 total]