Final Exam Tectonophysics, January 26 2016, 10-13:00. Points indicated in red.

Assignment 1. Gravitational potential energy in oceanic lithosphere

1 a) Why do lateral density variations result in horizontal forces within the lithosphere?

2 b) We consider two columns of oceanic lithosphere (Figure 1). Due to age differences, the columns have different average densities ρ_0 and ρ_1. The columns are in local isostatic balance (Pratt isostasy) at compensation depth L (base of lithosphere).

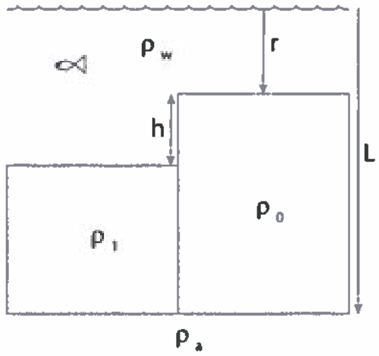

Figure 1

Find an expression for h as function of the densities.

2 c) Compute the total horizontal force due to lateral density variations from

$$F_x = -g\int_0^L \Delta\rho(z')z'\mathrm{d}z' \qquad (2)$$

where g is the gravity acceleration, L is depth of the base of the lithosphere from sea level, $\Delta\rho(z)$ is the lateral density contrast at depth z. Do not substitute your result for h (from b)) in this expression.

2 d) Briefly discuss your result from c) by explaining the force on the oldest column as follows; discuss the sign (compression/extension), and how variations in r and density will increase/decrease the force (hint: use realistic numbers and vary them, or substitute your expression from b) into the result of c))

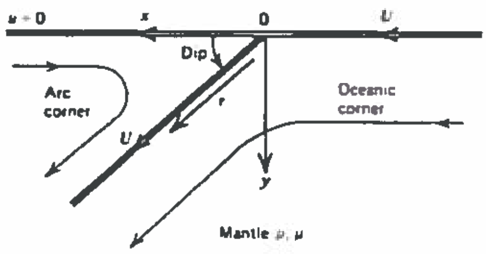

Figure 2

5 **Assignment 2. Slab dip.**

In class we derived the hydrodynamic pressure on an oceanic slab that results from the subduction velocity U of the slab into the asthenosphere (viscosity μ). The total lifting pressure resulting from flow in the arc corner and the oceanic corner is (Figure 2):

$$P = C\frac{\mu U}{r} \quad (3)$$

where $C(\alpha)$ is a constant depending on the dip angle α. Consider a slab with a uniform density contrast $\Delta\rho$ with respect to the asthenosphere, thickness H and length L, and that has a stable dip angle α ($30° \le \alpha \le 60°$). Derive an expression for the density contrast as function of μ, U and α.

Assignment 3. Literature

A fracture zone is a linear oceanic feature—often hundreds, even thousands of kilometers long—resulting from offsets of mid-ocean ridges. Different from transform faults, there is no horizontal slip on fracture zones. Oceanic lithosphere on both sides of fracture zones has different ages, and hence different subsidence (rates). This is the topic of the paper of Wessel and Haxby (1990).

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Thermal Stresses, Differential Subsidence, and Flexure at Oceanic Fracture Zones

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Geosat geoid undulations over four Pacific fracture zones have been analyzed. After correcting for the isostatic thermal edge effect, the amplitudes of the residuals are shown to be proportional to the age offset. The shape of the residuals seems to broaden with increasing age. Both geoid anomalies and available ship bathymetry data suggest that slip must sometimes occur on the main fracture zone or secondary faults. Existing models for flexure at fracture zones cannot explain the observed anomalies. A combination model accounting for slip and including flexure from thermal stresses and differential subsidence is presented. Our model accounts for lateral variations in flexural rigidity from brittle and ductile yielding due to both thermal and flexural stresses and explains both the amplitudes and the shape of the anomalies along each fracture zone. The best fitting models have mechanical plate thicknesses that are described by the depth to the 600°–700°C isotherms.

2 a) What is the research question?
1 b) How do the authors answer the research question?
2 c) What is the answer to the research question?
1 d) Why are thermal models relevant in the context of this paper?
1 e) Why is flexure relevant in the context of this paper?

Success!