Department of Geophysics, Faculty of Science, UU.
Made available in electronic form by the $\mathcal{T}_{\mathcal{B}}\mathcal{C}$ of A−Eskwadraat
In 2005/2006, the course GEO4-1401 was given by Jeannot Trampert.

Structure and composition of the Earth's interior (GEO4-1401) November 7, 2005

Question 1 *(20 points)*

There are at least three different arguments which indicate that compositional variations are present in the lower mantle, mostly from seismic tomography. Think of ratios of speed variations, differences in bulk sound and sheer wave velocities, but also density. Can you explain?

Question 2 *(20 points)*

Which is your preferred model which explains data from geochemistry and geophysics? Explain why.

Question 3 *(20 points)*

From seismology we know that there are two main discontinuities in the upper mantle. At what depth are they found, and what is the reason for their existence.

Question 4 *(10 points)*

What is the temperature of the lower mantle, and how well do we know it?

Question 5 *(30 points)*

We would like to investigate the possibility to calculate the composition in the lower mantle using mineral physics data. At a depth of 2200 km, the pressure is 100 GPa. Laboratory measurements for some mineral, at 0 GPa and 300 K, are: $K_0 = 264$ GPa and $\dot{K} = \frac{\partial K}{\partial T} = -0.015$ GPa/K. The equation of state is split into two parts. First the heating at zero pressure to the foot of the adiabat which is at the potential temperature T_p:

$$K(T_p) = K_0 + \dot{K}(T_p - 300)$$

The adiabatic compression from T_p and $P = 0$ is given by the second order Birch-Murnaghan equation of state:

$$\begin{aligned} \frac{\rho}{\rho(T_p)} &= (1+2f)^{\frac{3}{2}} \\ P &= 3K(T_p)f(1+2f)^{\frac{5}{2}} \\ K &= (K(T_p) + 7K(T_p)f) \cdot (1+2f)^{\frac{5}{2}} \end{aligned}$$

where $-f$ is the Eulerian strain.

a) The potential temperature is $T_p = 1800$ K. At a pressure of 100 GPa, is f equal to $9.0909 \cdot 10^{-2}$. Is this value of f reasonable? Why?

b) Calculate the bulk modulus of this mineral at 100 GPa and the potential temperature $T_p = 1800$ K. Compare this value to the earth model PREM which gives 545 GPa for K.

c) We now put some iron in the system. The laboratory measurements show that K_0 is reduced by 10% if we include 20% iron. How much iron do we need to match PREM? Is this plausible?