**SOEE2212 Tectonophysics Lab 3: Heat flow and the depth of the ocean floor**

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**1. Theory**

You will recall from the lab that the half-space cooling model for oceanic lithosphere predicts that the depth of the ocean below the mid-ocean ridge, w, increases with and can be calculated as follows:

(1)

[see chapter 4 of [Turcotte and Schubert (2002](#_ENREF_2)) for the derivation of this and other expressions here.]

For old oceanic plates, we saw that the depth flattened off. The “plate model” of [Parsons and Sclater (1977](#_ENREF_1)) suggests at , the plate reaches a constant thickness, , where temperature of the base is maintained by convection in the earth’s interior. It can be shown that

(2)

The models also make predictions for the heat flux as a function of time. These are:

(3)

(4)

The table below gives the values of some constants that you may need.

|  |  |
| --- | --- |
| Density of the mantle | 3300 kg m-3 |
| Density of seawater | 1025 kg m-3 |
| , Temperature of the mantle | 1300 °C |
| , Temperature of seawater | 0 °C |
| , Volumetric coefficient of thermal expansion | 3.1 x 10-5 °K-1 |
| , Thermal diffusivity | 0.8 x 10-6 m2 s-1 |
| , Thermal conductivity | 3.3 W m-1 °K-1 |
|  |  |

**2. Aims of the lab**

1. To examine the relationship between age of oceanic plates and the depth of the seafloor.
2. To test understanding of the half-space cooling and plate models.
3. To determine the thickness of the lithosphere in old oceanic plates.
4. To explore the uncertainties and assumptions in these calculations.

**3. Data sets**

1. Digital grid of age of the oceans

<http://www.earthbyte.org/Resources/agegrid2008.html>

1. Digital grid of bathymetry from ship tracks and satellite altimetry

<http://topex.ucsd.edu/marine_topo/>

1. Heat flow data from the global heat flow data base

<http://www.heatflow.und.edu/index2.html>

I have downloaded these data sets and cut out sections for the North Atlantic.

**4. Getting started**

Download the zip file: <http://see.leeds.ac.uk/~eartjw/data/tectonophysics/lab3.zip> and unzip.

Open matlab and move into the lab3\_files directory. Add mbin to your path:

*> addpath mbin*

**Keep all your commands in a script and run this, rather than running them on the command line.**

**5. Task 1: the analytical models**

I have provided two functions, depth\_halfspace.m and depth\_plate.m that enable you to calculate *w* as a function of age.

**Produce plots of depth vs age for the two models using a set of reasonable parameters. Also plot depth vs for the two models.**

To do this, make a vector of ages, e.g.

*> t = [0:250];*

**Note that for the plate model, the depth depends on the sum of an infinite series. Explore how many terms are required before the solution converges.**

Remember, for instructions on how to use Matlab functions, you can type:

*> help function\_name*

**6. Task 2: compare the models with real depth vs age data**

As discussed in section 3, I have provided grids of elevation/bathymetry and ocean age for the north atlantic. These are:

*elevation\_northatlantic* and *age\_northatlantic*

You can view the images and load the grids into memory using the function *show\_ers,* e.g.:

*> elev=show\_ers(‘elevation\_northatlantic’);*

**View the grids and think about where the best place to extract a depth vs age profile would be. What are the difficulties in selecting an appropriate location?**

Now extract depth and age profiles from the real data using the function *main\_prof,* e.g. :

*> [prof\_depth] = main\_prof('elevation\_northatlantic',50);*

Where the argument, 50, in this case means average all data within 50 km of the profile line (you may wish to change this value).

When you run *main\_prof* for the first time, you will be asked to select a profile. Do this by clicking with the left button on the start and end points of the profile, and then hitting enter. Subsequent runs of *main\_prof* will use the same profile, stored in file *profdef.dat.* You can edit this file to change the location of the profile, or select a new one by deleting the file and running *main\_prof* again.

**Plot depth against age (and ) for a representative profile. At what age does depth deviate from the linear relationship?**

**Plot theoretical depth curves on top of the real data, and adjust the parameters in the half-space and plate models to match the data.**

**What is the thickness of the lithosphere? How well constrained is this by these data (i.e. what range of *yL*** **would fit the data equally well?**

**Repeat the process for several profiles. How consistent are the results?**

**What assumptions have gone into your estimates of lithospheric thickness?**

**6. Task 3: Compare the solutions with heat flow data**

The file *LonLatHeatAge.txt* contains four columns with Longitude, Latitude, Heat Flow (mW m-2), Age (Ma). Load this into matlab (with *load* function).

**Make a map showing coloured dots for all the observations, where the colour is proportional to the heat flow.** [Use matlab command *scatter,* and you will probably want to change the range of colours displayed using *caxis, e.g. > caxis([0 200])* ].

**Plot heat flow as a function of age of oceanic crust.**

By modifying the codes *depth\_halfspace.m* and *depth\_plate.m*, make functions that use the equations in section one to predict heat flow as a function of age.

**Plot the analytical solutions on top of the heat flow observations and comment on the results.**

**References**

PARSONS, B. & SCLATER, J. G. 1977. An analysis of the variation of ocean floor bathymetry and heat flow with age. *J. geophys. Res,* 82**,** 803-827.

TURCOTTE, D. L. & SCHUBERT, G. 2002. *Geodynamics*, Cambridge Univ Pr.