**Problem set 2**

**Learning Goal:**

*To fit ideal diffusion profiles produced under controlled conditions in a laboratory.*

*To see how Arrhenius relations, used later for retrieving timescales, are produced.*

*Develop an awareness of some of the uncertainties involved.*

***The Background.*** Many timescales in igneous rocks are obtained by modeling zoning profiles of Fo/Fa in olivine. For this, the Fe-Mg interdiffusion coefficients in olivine, D(Fe-Mg), are used. Diffusion coefficients measured by Chakraborty (1997), and the Arrhenius relation obtained by fitting these data, have been widely used for this purpose. In this exercise, we will try to fit some of the experimental diffusion profiles from that study, and obtain an Arrhenius relationship.

***The Experiments.*** Chakraborty (1997) took gem quality single crystals of olivines of two different compositions and a crystallographically oriented surface was polished on each. The crystals were pressed together along these surfaces for a defined period of time in a furnace maintained at a controlled temperature and oxygen fugacity. After this, the crystals were taken out (they bond together at this point), cross sections were prepared for microprobe analysis, and concentration profiles were measured.

***The Problem.*** The file **Problem set 2.xls** contains concentration profiles from 4 such experiments (data from each experiment is in a separate sheet) carried out at different conditions. The relevant information (compositions, duration of anneal, temperature, oxygen fugacity) are given in the respective sheets.

For these controlled experiments, you know time, t, and the diffusion coefficient, D, is the unknown.

**(a)** Calculate simulated diffusion profiles and vary the diffusion coefficient until you obtain a good match to the experimentally determined profiles. Once you have that, you have determined the diffusion coefficient at that condition.

**(b)** Repeat this for all the experiments, and collect the data together in a spreadsheet. Make an Arrhenius plot, and fit the data to extract an Arrhenius relation i.e. a D0 and Q in the equation D = D0 exp (-Q/RT).

You will need to think how to obtain Q and D0 from the linear fit in the Arrhenius diagram.

**Thought question:** Consider some of the uncertainties that may arise as you go along. The activation energy you obtain, Q, is somewhat different from the one given in the publication by Chakraborty (1997). Why is this so? This is an important consideration when you evaluate data from the literature later for modeling your profiles.

**Reference:**

Chakraborty, S. (1997) Rates and mechanisms of Fe-Mg interdiffusion in olivine at 980- 1300oC, *Jour. Geophys. Res.*, 102, B6,12317-12331.