Notes about this exercise: As is, it was used in a graduate course in structural geology, but could be rejigged without too much effort to be used in an undergraduate course as it uses simple equations, simple values, simple conditions and simple changes in conditions. The exercise was preceded by a standard lecture with class notes and a reading provided (that could be changed). The exercise was actually a “double” – homework and full class discussion (20 to 30 minutes). The class discussion was where synthesis and instructor evaluation of student learning also occurred. Hence, those parts are not present in the text of the exercise. The exercise could be done entirely in class but the time for the second part (discussion) needs to be retained. It can be a second part or it can be folded into the workflow, but it is needed because it is vital to achieving synthesis and learning assessment. Please note that I crafted this exercise around a sequence of rock types and deformation conditions for which I have much familiarity. The exercise could be rebuilt to fit rock suites, geometries and deformation conditions for which you have experiential and intuitive familiarity. And yes, some of the boundary stress conditions will not happen in the real world, but increasing the complexity of the stress description and analysis does not improve the student learning, and it does no real harm to simplify for purposes of the learning with respect to this topic (personal opinion!).

**Rheology Homework – Thought Questions**

We will consider five scenarios involving a trio of layers that each has different rheological properties (elastic, viscous, plastic) to provide you with some insight into basic rheological behaviors. Let’s consider a situation where we are deforming a sedimentary sequence by regional shortening parallel to the horizontal and initially horizontal bedding at about 225oC. Let that sequence contain 5m-thick beds of a medium-grained, pure dolomite (approximately elastic, not inclined to deform by much of any mechanism, except perhaps some fracturing processes), a fine-grain limestone with about 5% clay minerals (approximately viscous – deforming by diffusion, grain-boundary sliding and grain-boundary migration mechanisms), and a medium to coarse-grained, pure quartz arenite (approximately plastic – deforming by mainly dislocation glide with some dislocation creep).

**Rheological (material) properties of the three lithologies:**

Dolomite – Young’s modulus = 50 GPa

Limestone – Coefficient of Viscosity = 6 x 1021 Pa S

Quartz arenite – Yield stress = 50 MPa

You can use these material properties to calculate strain for an elastic material, strain rate for a viscous material, and determine if you will have strain for a plastic material. In the case of the plastic material, you would need additional information to determine the strain magnitude if the plastic material is deforming independently, which is NOT always the case in these five scenarios. Remember when performing these calculations that you are working in SI units, that M=Mega (106), G=Giga (109), and converting seconds to years, if needed, is 60x60x24x365 or 31,536,000 seconds per year!

**Scenarios:**

1) Each layer is separate and able to act independently. Each experiences a constant applied stress of 40 MPa where the other effective principal stresses are zero. What happens in each layer after 1 second, after 1 year, and after 1 million years?

2) Each layer is separate and able to act independently and each experiences an increasing applied stress from 40 to 100 MPa (other effective principal stresses are zero) over 1 million years. What happens in each layer after 1 second, after 1 year, and after 1 million years?

3) Like #1, but layers are now adjacent (dolomite on top, limestone in the middle, quartz arenite at the bottom), and assume that other layers and layer-boundary properties in the system do not matter. The layer boundaries between the three layers have no adhesion. What happens in each layer after 1 second, after 1 year, and after 1 million years?

4) Like #3, but layers now have perfect adhesion at the contacts between them (other layers and layer boundaries still do not matter). What happens in each layer after 1 second, after 1 year, and after 1 million years?

5) Like # 4, with additional restriction that layers must maintain the same lengths during deformation. What happens in each layer after 1 second, after 1 year, and after 1 million years?