Fabrics, folds and deformation mechanisms
Or:
“What went down in the last month?”

Fall 2005

The purpose of these notes is to give you an overview of the material that will be the focus of the final exam. This, and the review questions, should help you focus your attention. Also, I intend to have the topic by topic course notes out, but this should help you for the time being.

1 Folds

1.1 Descriptive terminology

There’s a considerable amount of descriptive terminology for folds. While I doubt that any question on the exam will directly ask you to, for instance, define what it means for a fold to be non-cylindrical, it would be useful for you to make sure that you are familiar with the descriptive terminology for folds. The introductory material on the lab on folds is a good starting point; chapter 11 in Twiss and Moores covers this in greater depth.

1.2 Kinematic models of folding

Be familiar with the general ideas behind flexural slip, buckling and passive flow models and the effects of homogeneous shortening superimposed on these models. Make sure you can draw the strain ellipses in the different regions of a folded layer for each of these models. Consider the behaviour of a linear marker thatŠs folded in these ways. Pages 315 – 320 in the text are useful in this regard. Also to review is the control on wavelength of folding by thickness and viscosity contrasts and the behaviour of folded multi-layers. Don’t worry about memorizing the exact equations, but know qualitatively the first-order controls. These relationships, of course, assume a specific kinematic model.

1.3 Super-posed folding

The patterns of super-posed folding are typically categorised into Types I, II, and III. These different patterns reflect the relative orientations of the fold hinges and axial surfaces of the first and second folds. Make sure you understand how you can generate these patterns.

2 Fabrics

2.1 Foliations

Planar fabrics can form in a shear zone, or may form in a specific geometrical relationship to a series of folds. Depending on the rock, foliations may include spaced fracture cleavage, slaty cleavage, crenulation cleavage, schistosity, gneissosity. (Other planar fabrics include flow foliation, which may not be related to tectonic deformation per se). In folded rocks, planar fabrics are commonly parallel to the axial plane of the fold. You might find it useful to think of examples where this might not be the case (consider an interbedded quartzite and shale being folded). Foliations in folded terrains can be extremely useful: if they are truly parallel (or close to parallel) to the axial plane, the intersection of the layer being folded and the foliation will result in a line that is parallel to the fold axis. Moreover, there is a specific geometrical relationship between bedding and axial planar foliation that allows you to infer the position of fold closures. These are key relationships that are the bread and butter of field geology in folded terrains. See section 13.5. Once a foliation is formed, it can be modified by further deformation. Some processes: rotation during shear (see fig 14.4 for different mechanisms of rotation), small scale folding (crenulation), recrystallisation. See chapters 13 and 14 for material on the formation and modification of planar and linear fabrics (they are short chapters). The preservation of earlier generations of fabrics within porphyroblasts (eg. garnet) and within low strain zones (the hinges of later folds) is exploited by geologists who then label them S1, S2, S3 etc... Of particular importance is the concept of transposition foliation. Such a fabric is a composite fabric: multiple generations of planar features are found to be parallel. The common case is to find compositional layering (e.g. bedding, called S0) parallel to a tectonic fabric. How does this happen? (Chapter 13). In areas of multiple deformations, you can have synformal anticlines and antiformal synclines and so on. The key to working this out is to be able to establish “younging” (or “way up”), and the geometrical relationship between the limb of a structure and an axial planar fabric. Study and be able to reproduce figure 13.15 – it is a favorite of Clark’s.

2.2 Lineations

Distinguish between intersection lineations, mineral lineations and stretching lineations. Be able to describe a few examples of each. Again, chapters 13 is the key one for that. Note that some mineral lineations will be parallel to a principal strain axis, but some will not. Stretching lineations are usually indicative of the maximum stretching orientation. Intersection lineations often reflect a fold geometry. Explain the relationship between a boudin line lineation and the maximum extension direction.

3 Deformation mechanisms

What’s the difference between brittle and plastic deformation? Is plastic the same as ductile deformation? Plastic deformation mechanisms include twin glide, dislocation glide, dislocation creep, recovery, static recrystallisation. Dislocation creep, in common usage, refers to a set of processes: dislocation glide, recovery via subgrain rotation and grain boundary migration. You should review chapter 19 on this, or Passchier and Trouw. Section 19.7 and onwards deals with issues surrounding the formation of crystallographic preferred orientation. Don’t worry too much about this, but do know the difference between fabric as defined by the preferred orientation of minerals (mica flakes making a foliation, or stretched quartz grains defining a stretching lineation) and a crystallographic preferred orientation. An important thing to note about plastic deformation mechanisms: they are sensitive to temperature, strain-rate, grain size, the presence of fluids but more than that, the specific behaviour is material dependant. That is, twin gliding occurs in calcite but not quartz, dislocation glide occurs in marbles and limestones at low temperatures, quartz at moderate temperatures and so on. Some minerals, such as garnet, never deform plastically. This means that for any given polymineralic rock, the overall bulk strain is going to be accommodated in a heterogeneous fashion in a rock.