Metamorphic Textures

Reading: Winter, Chapter 23

Metamorphic Textures

Textures are small-scale penetrative features

Relict Textures
- Inherited from original rock
- “Blasto-” = relict
- Any degree of preservation
- Pseudomorphs of minerals or pre-
  metamorphic textures/structures

Metamorphic Textures

Processes of Deformation, Recovery, and Recrystallization

1. Cataclastic Flow
   - Mechanical fragmentation and sliding,
     rotation of fragments
   - Crush, break, bend, grind, kink, deft
     twins, undulose extinction, shredding of
     micas, augen, mortar, etc.
   - Technically not metamorphic

2. Pressure Solution
   - Figure 23-2 a. Highest strain in areas near grain contacts (hatch pattern). b. High-strain areas dissolve and material
     precipitates in adjacent low-strain areas (shaded). The process is accompanied by vertical shortening. c. Pressure solution
     of a quartz crystal in a deformed quartzite (s is vertical). Pressure solution results in a serrated solution surface in high
     strain areas (small arrows) and precipitation in low-strain areas (large arrow). ~ 0.5 mm across. The fretting within this
     grain is a hematite stain along the original clast surface. After Hibbard (1995) Petrography to Petrogenesis. Prentice Hall.

3. Plastic Intracrystalline Deformation
   - No loss of cohesion
   - Several processes may operate simultaneously
     - Defect migration
     - Slip planes
     - Dislocation glide
     - Deformation twinning

4. Recovery
   - Loss of stored strain energy by vacancy migration, dislocation
     migration and annihilation
   - Polygonization- general term for formation of low-strain subgrains
Metamorphic Textures

5. Recrystallization
   - Grain boundary migration
   - Subgrain rotation
   - Solid-state diffusion creep at higher T
   - Crystalplastic deformation (general term)

   - Grain boundary sliding and area reduction
   - Coalescence - recovery and recrystallization by which large grains form by the addition of smaller strained grains by grain boundary migration

Recrystallization by grain boundary migration and sub-grain rotation

Dislocation migration forms two strain-free subgrains

Coalescence - recovery and recrystallization by which large grains form by the addition of smaller strained grains by grain boundary migration

High-Strain Metamorphic Textures (shear zones)

Figure 23-4 a. Undulose extinction and (b) elongate subgrains in quartz due to dislocation formation and migration Winter (2001)

Figure 23-5. Illustration of a recovery process in which dislocations migrate to form a subgrain boundary. Winter (2001)

Figure 23-6. Recrystallization by (a) grain boundary migration (including nucleation) and (b) subgrain rotation. From Passchier and Trouw (1996), Microtectonics.

Figure 23-7a. Recrystallized quartz with irregular (sutured) boundaries, formed by grain boundary migration, width 0.2 mm. From Borradaile et al. (1982).

Figure 22-2. Schematic cross section through a shear zone, showing the vertical distribution of fault-related rock types, ranging from non-cohesive gouge and breccia near the surface through progressively more cohesive and foliated rocks. Note that the width of the shear zone increases with depth as the shear is distributed over a larger area and becomes more ductile. Circles on the right represent microscopic views or textures. From Passchier and Trouw (1996), Microtectonics, Springer-Verlag, Berlin.
High-Strain Metamorphic Textures

- Concentrate on cataclastic > ductile (shallower)
  - Break, crack, bend, crush, rotate
  - Slip and shredding of phyllosilicates
  - Clasts - broken remnants
  - Porphyrystal- larger remnant in finer crush matrix
    - Mortar texture
    - Ribbons
  - Pseudotachylite

Textures of Contact Metamorphism

- Typically shallow pluton aureoles (low-P)
- Crystallization/recrystallization is near-static
  - Monomineralic with low D surface energy
  - Larger D S.E. form decussate
  - Isotropic textures (hornfels, granofels)
  - Relict textures are common


**The Crystalloblastic Series**

**Most Euhedral**
- Titanite, rutile, pyrite, spinel
- Garnet, sillimanite, staurolite, tourmaline
- Epidote, magnetite, ilmenite
- Andalusite, pyroxeine, amphibole
- Mica, chlorite, dolomite, kyanite
- Calcite, vesuvianite, scapolite
- Feldspar, quartz, cordierite

**Least Euhedral**


**Metamorphic Textures**
- Contact overprint on earlier regional events are common
  - Thermal maximum later than deformational
  - Separate post-orogenic (collapse) event
- Nodular overprints
- Spotted slates and phyllites
Figure 23-14. Overprint of contact metamorphism on regional.  
(a) Nodular texture of cordierite porphyroblasts developed during a 
thermal overprinting of previous regional metamorphism (note the 
foliation in the opaques). Approx. 1.5 x 2 mm. From Bard (1986). 
(Microtextures of Igneous and Metamorphic Rocks. Reidel. Dordrecht.)

(b) Spotted phyllite in which small porphyroblasts of cordierite 
(Microtextures of Igneous and Metamorphic Rocks. Reidel. Dordrecht.)

Figure 23-13. Light colored depletion haloes around cm-sized 
garnets in amphibolite. Fe and Mg were less plentiful, so that 
hornblende was consumed to a greater extent than was plagioclase 
as the garnets grew, leaving hornblende-depleted zones. Sample 
(An Introduction to Igneous and Metamorphic Petrology. Prentice Hall.)