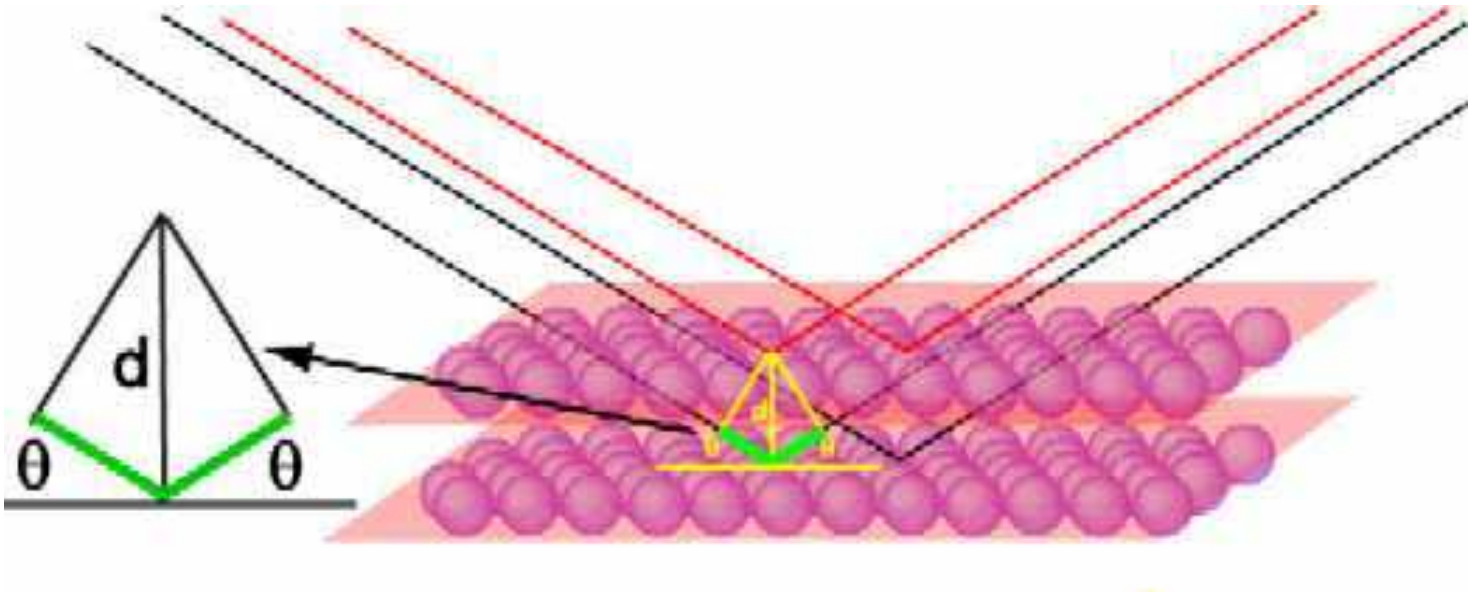
Announcements

- Reading: p.46-47; look at Chapter 2 and 3 in your book!
- Homework 1 is on the website. Due:
- Field trip 1:

Minerals vs. Melt

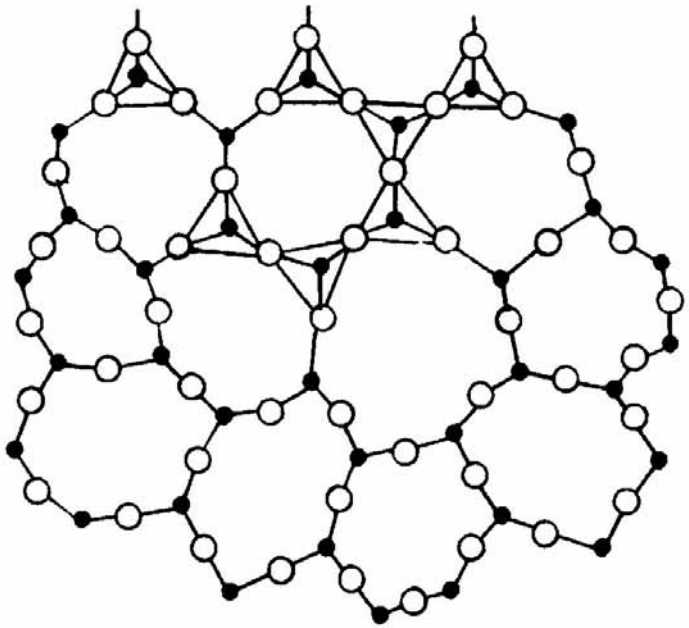
- How do we determine the structure of minerals?

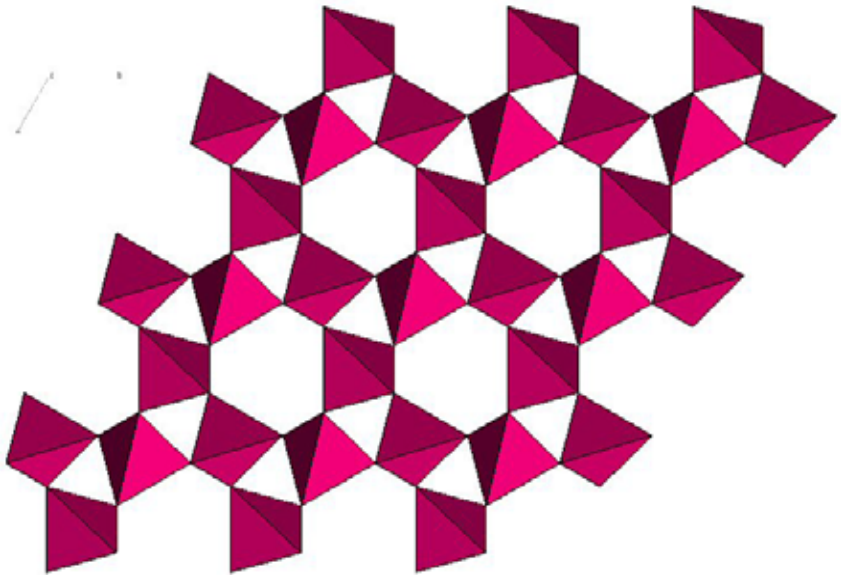


- What are differences between minerals and melt?

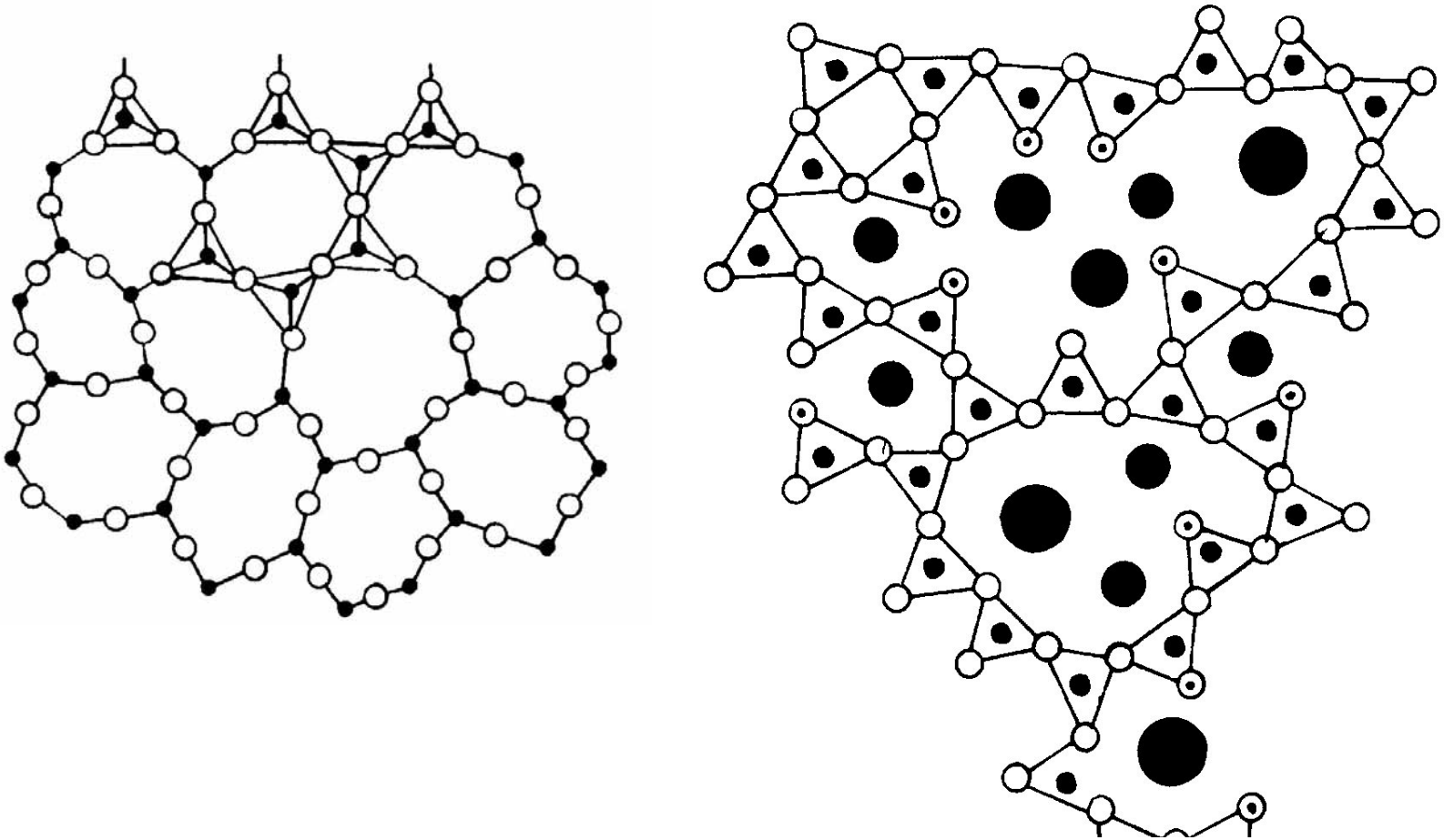
Structure of silicate melts

- Polymerization and short-range order





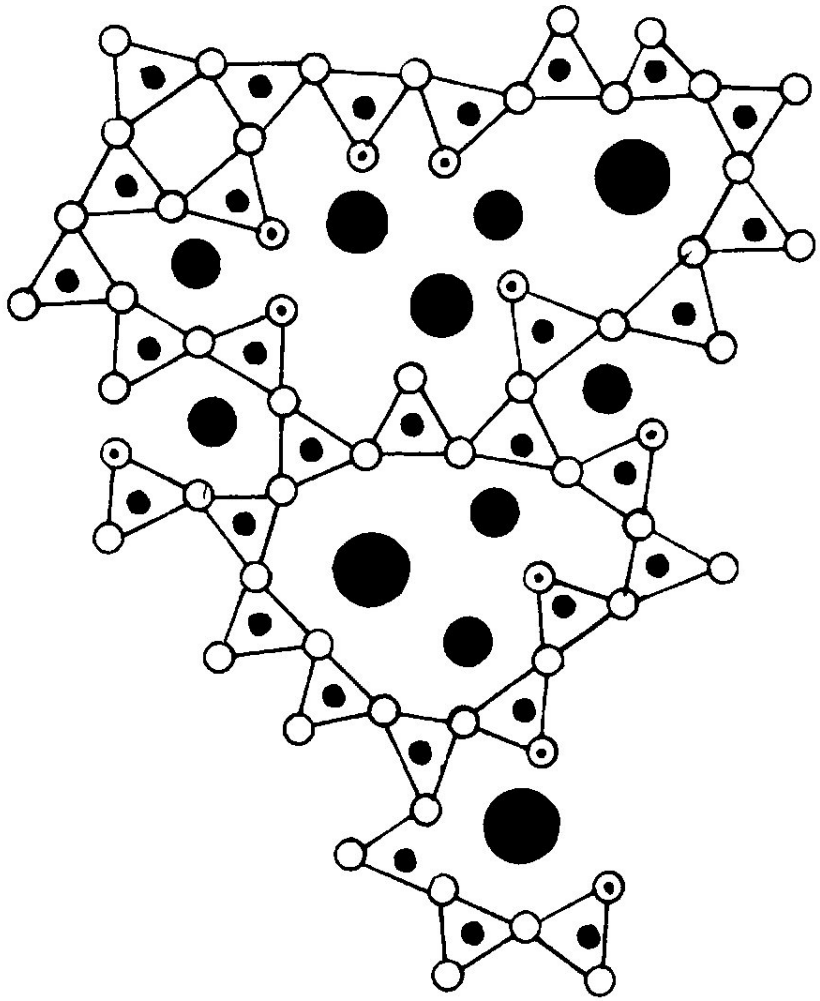
Non-structural cations



How do we know what the structure of silicate melt looks like?

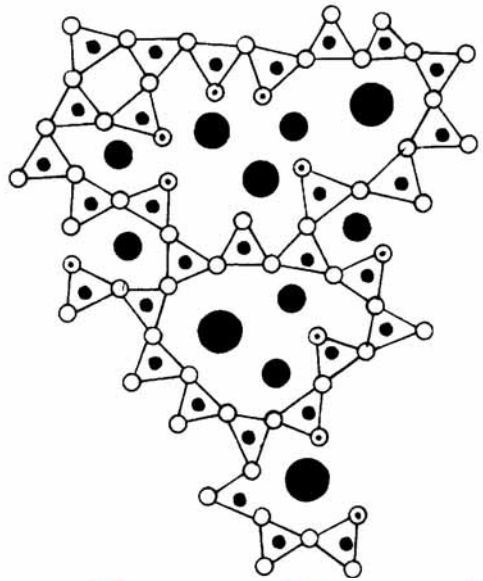
Effect of melt structure on geochemistry

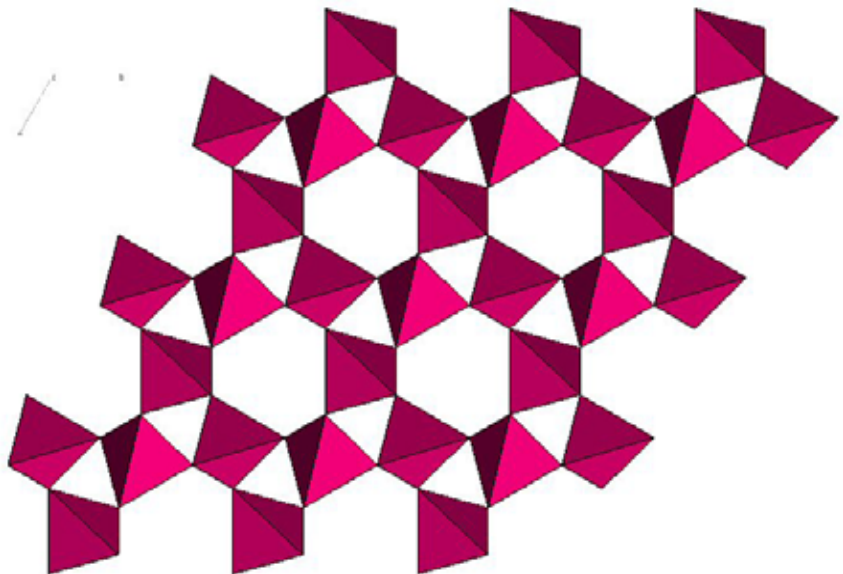
- Big cages for large cations:
  - preferential partitioning of large, low charge cations into melt
  - volatiles: CO_2, He, Ne, other noble gases, H_2O, sulfur species



Effect of melt structure on melt density

- Melt densities:
  - 2.2-3.1 g/cm^3
- Rock densities:
  - 2.8-3.3 g/cm^3
- How does this affect melt migration?





Magma Viscosity

- Why would we care about viscosity?
  - Does a melt get erupted or get trapped in the crust or mantle?
  - How fast and far can a melt travel?

- What is viscosity? How viscous are silicate melts? ☺

Viscosity

- Definition:

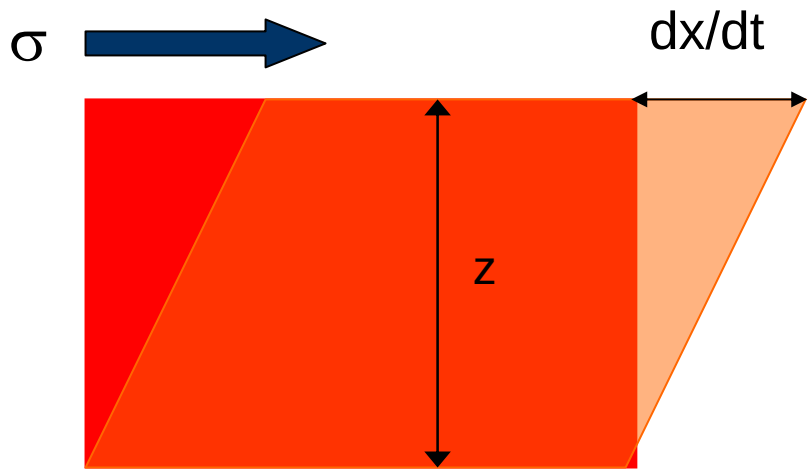
$$\eta = \frac{\sigma}{(dx/dt)/dz}$$

- Units of measurement:

  1 poise = 0.1 Pa-second

- How viscosity is measured (Stoke's Law)

$$\eta = \frac{2(\Delta\rho)r^2g}{9v}$$



σ = shear stress

z = layer thickness

dx/dt = rate of permanent deformation parallel to the shear stress

Viscosity of foods

Poise
x10

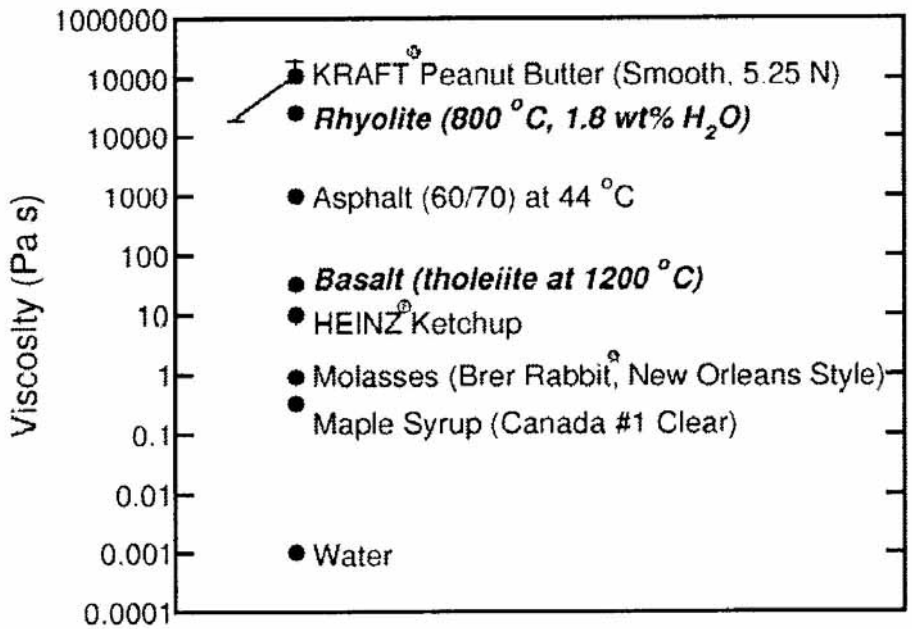
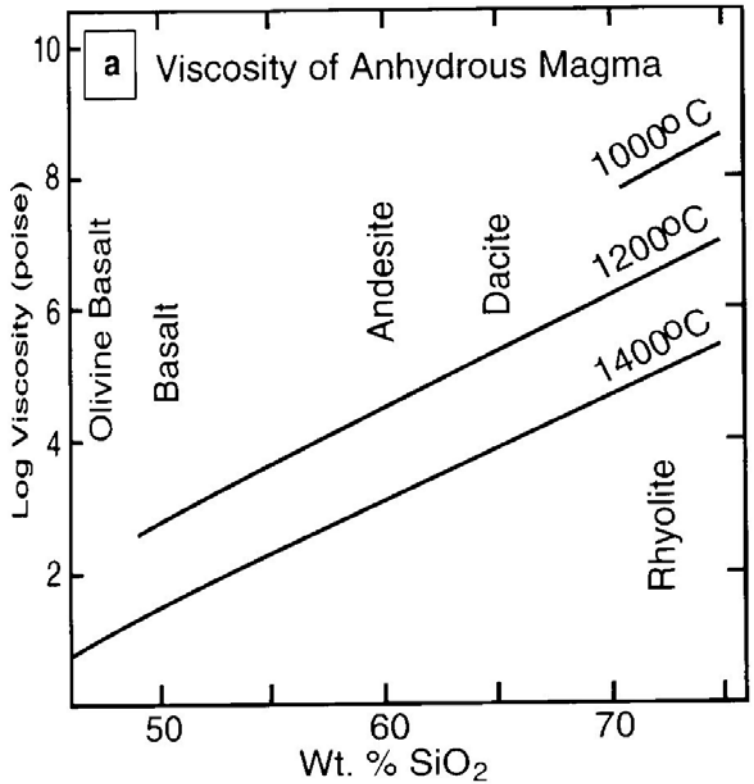


Figure 3. Viscosities of selected foods at 25 °C (from this study), water at 25 °C (Bauer et al., 1995) and asphalt at 44 °C (Shaw et al.,1968) compared with those of an anhydrous basaltic melt at 1200 °C (Shaw, 1969) and a rhyolitic composition melt with 1.8 wt % dissolved water at 800 °C, 1.0 GPa (Baker, 1996). Measurement uncertainties are smaller than the symbols except for peanut butter viscosity, whose lower error is displaced for clarity. The silicate melts span the range of commonly expected viscosities for terrestrial silicate melts (Basaltic Volcanism Study Project, 1981; Hess, 1989).

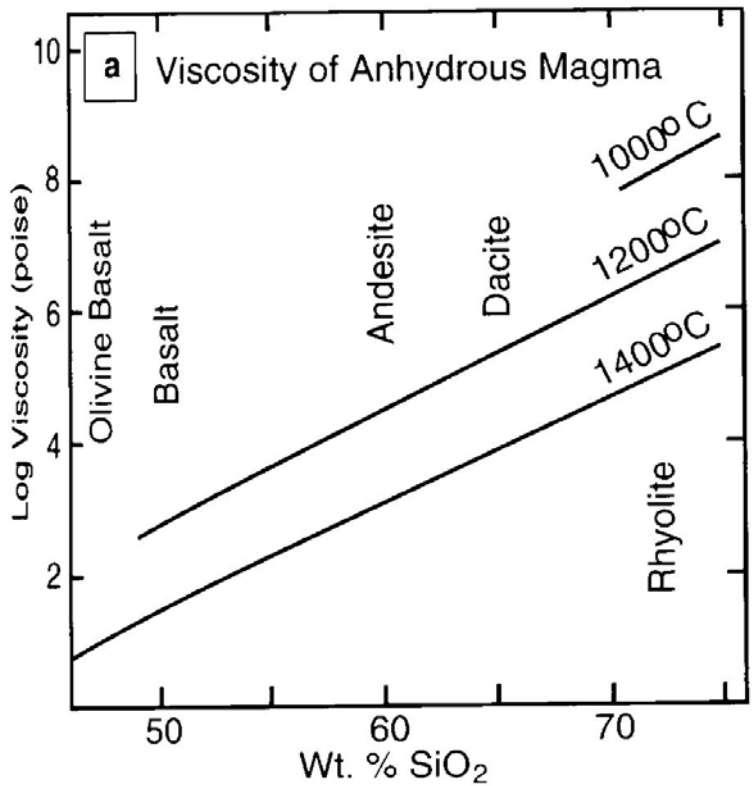
Viscosity of melts

- Composition affects viscosity
- Greater polymerization = greater viscosity

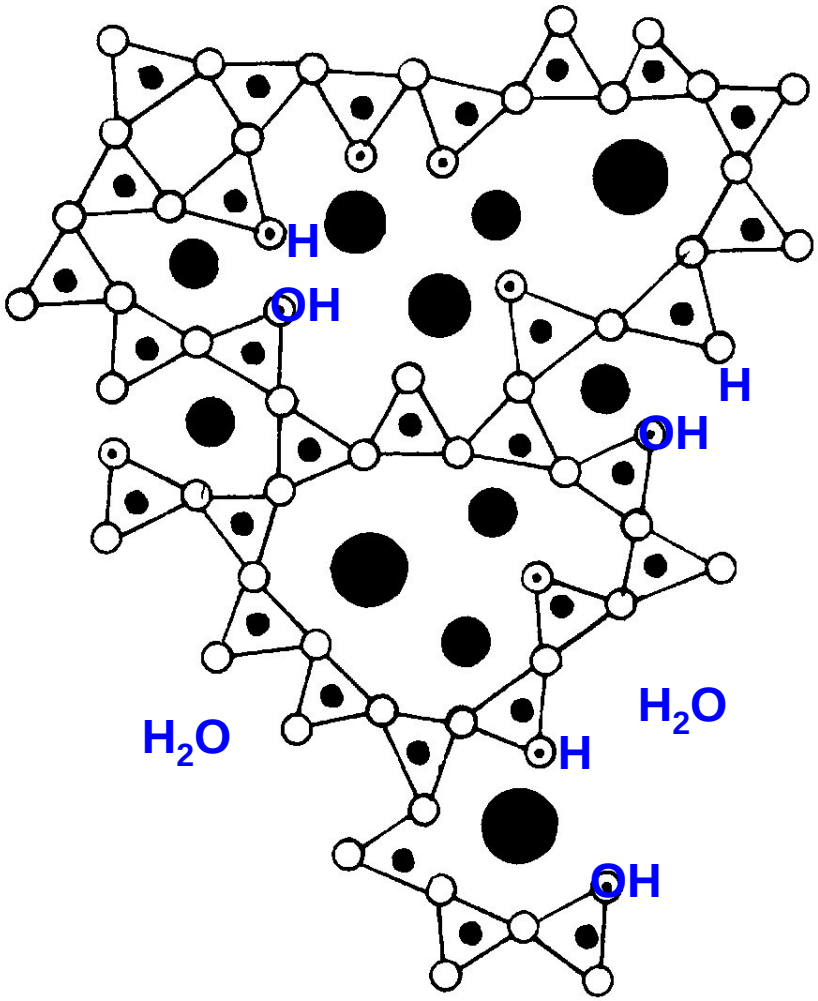


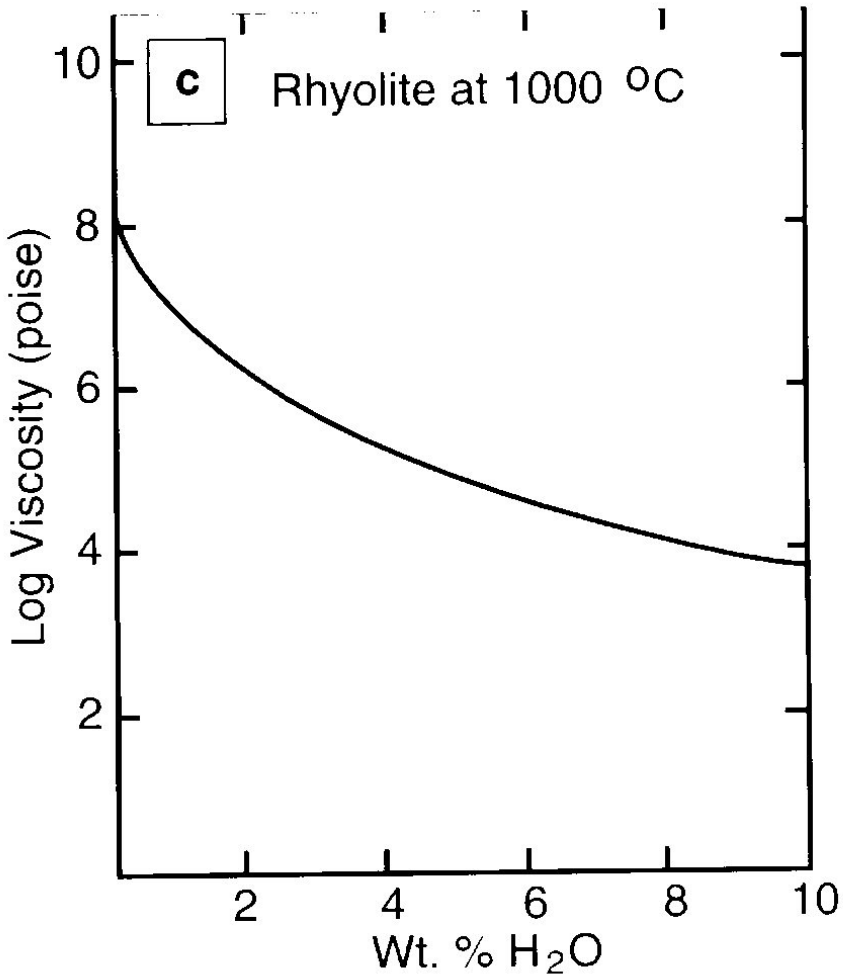
Modification of viscosity

- Bubble formation and growth
- Crystallization
- Water content
- Temperature



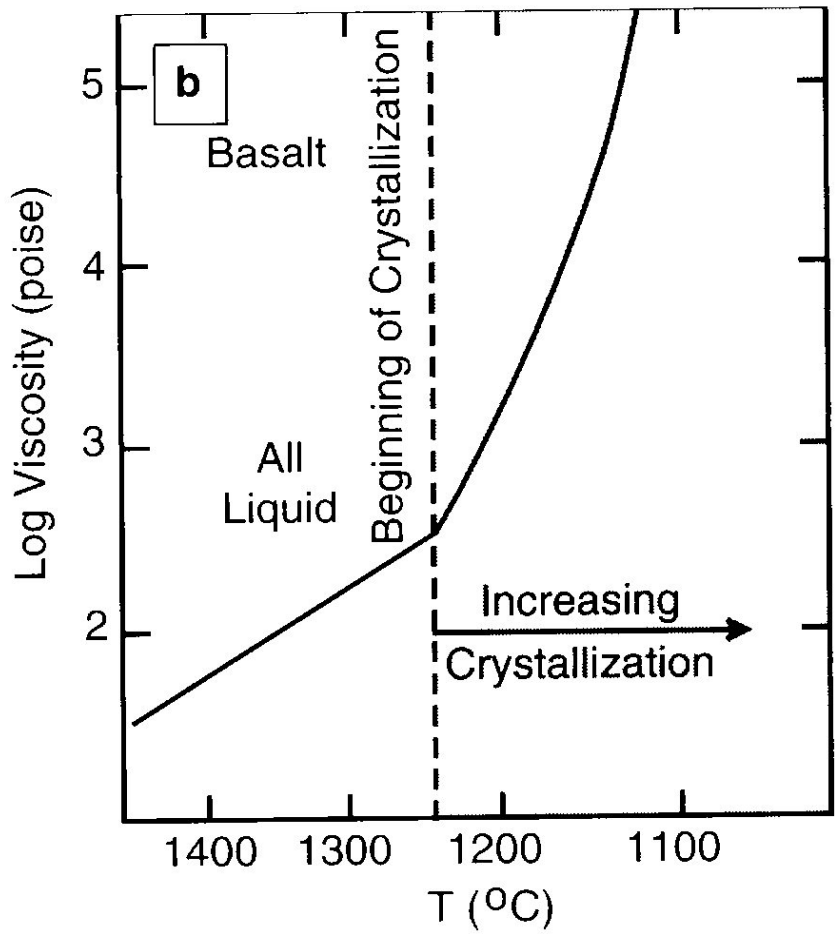
Water: effect on viscosity





Water, bubbles, crystals

- Water lowers viscosity
- Also causes crystallization at lower T: increases viscosity
  - (chunky vs. smooth peanut butter)
- Bubbles form- increases viscosity



Important Ideas

- Silicate melts have open structures and local ordering
  - can accommodate many volatiles, large cations, noble gases
- Typical densities: 2.2-3.1 g/cm^3
- Typical viscosities
  - 500-1,000,000 poise
- Water, bubbles, crystallization, and T all affect melt viscosity