Structural Controls

- This segment considers factors in the lithospheric that favor volcanism
- What allows magma to pass through the rigid crust onto the surface?

Large-scale Stress Regimes

- Compression
  - Mostly in subduction zones
- Tension
  - Mid ocean ridges
  - Back arc basins
  - Rift zones

Local Stress Regimes

- Folding of a slab
- Strike-slip faulting
- Magma intruding a dike
- Magma in a sill
- Magma in a cylindrical conduit
- Magma in a chamber

Stress and Strain

- Stress is the force per unit area
  \[ \sigma = \frac{F}{A} \]
- Strain is the amount of change in length of an object
  \[ \varepsilon = \frac{\Delta l}{l_0} \]

Stress Ellipse

- Three principal stress axes
  - \( \sigma_1, \sigma_2, \sigma_3 \)
- Major and minor stress axes
- Lithostatic stress
  \( \rho g z = \) stress of overburden
  - May be the maximum, minimum or intermediate stress

Strain Ellipse

- Position of maximum extension (tension)
- Position of maximum compression
- Simple Shear
  - Card deck model
  - A circle becomes and ellipse
- Lines of no net change = \( l_0 \)
- Determination of strain from model
Relation of Stresses to Faulting

- If $\sigma_1$ is vertical
  - Normal faults occur with a dip $\approx 60^\circ$
- If $\sigma_2$ is vertical
  - Transcurrent faults occur and the slip direction is horizontal
  - The fault plane is vertical
- If $\sigma_3$ is vertical
  - Thrust faults occur with a dip $\approx 30^\circ$

Tension?

- Where does tension occur in the rigid earth?
- At a bent slab
  - Stretched zone, neutral cone compressed zone
  - Subduction environments, upper and lower plates
- Dominantly horizontal strain
  - Where $\sigma_1$ is horizontal
  - Normal faults
  - Rifting environments

Dikes or Sills?

- What factors favor dikes vs. sills?
- Orientation of principal stresses
- If least principal stress ($\sigma_3$) is vertical, sills are favored
- If intermediate principal stress ($\sigma_2$) is vertical, dikes are favored

Dikes as Stress Indicators

- Parallel dike swarms
  - Canada
  - USA
  - Scotland
- Dike azimuth is perpendicular to $\sigma_3$

Radial dike swarms

- Dike Mountain, CO
- Spanish Peaks, CO
- Theoretical model of radial dikes in a stress field

Segmented Dikes

- Geometry is like a hand and fingers
- Caused by rotation of least principal stress near the surface
- Buds on dikes may form conduits to the surface
Scoria Cone Fields

- Characterized by
  - Aspect ratio (L/W)
  - Orientation

- Scoria fields may be stress indicators
  - Field, chains of craters, and fissures are elongated in direction normal to least principal stress

- Examples from western USA and Mexico
  - Pinacate
  - Uinkaret