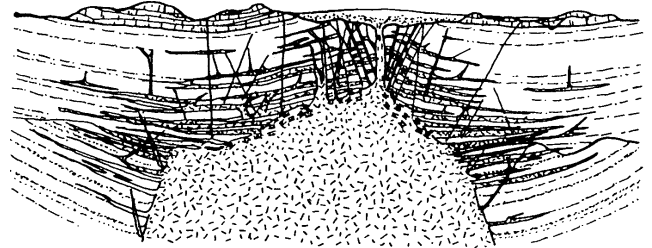


Magma Emplacement

Christiansen and Best,
Chapter 9

Room Problem

How to accommodate for the volume of the batholith?



How to Accommodate Plutons in the Crust?

A huge volume is involved in batholithic intrusions

Processes:

1. Thicken the crust by displacing the Moho downward
2. Lifting the surface of the Earth
3. Exchange positions of magma from lower crust to upper crust

Granite Plutons

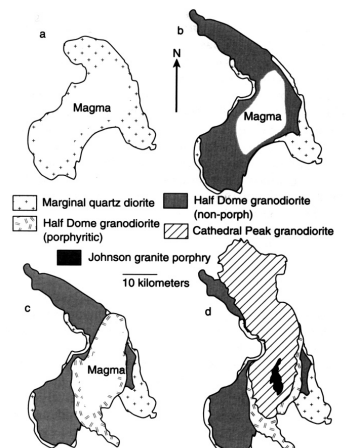
- Generally inhomogeneous in composition
- Composite intrusions
 - Emplacement of two different magmas
- Zoned intrusions
 - Concentric gradations

Composite Intrusions

- Compositionally or texturally different
- Chilled, fine-grained inner contact
- Variable time intervals (and cooling histories) between intrusions

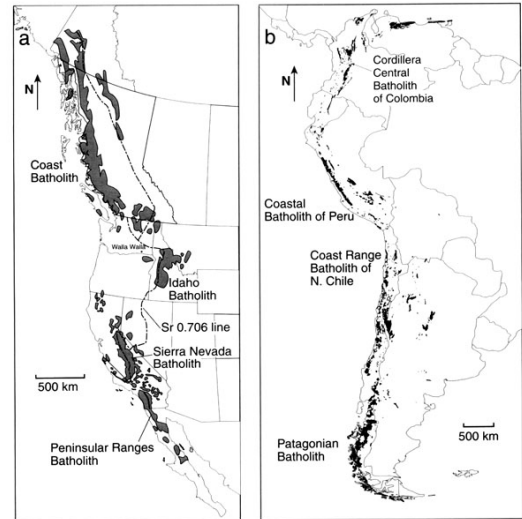
Zoned Intrusions

- Concentric parts
- Successively less mafic inward
- Gradational contacts
- Assimilation of country rock?



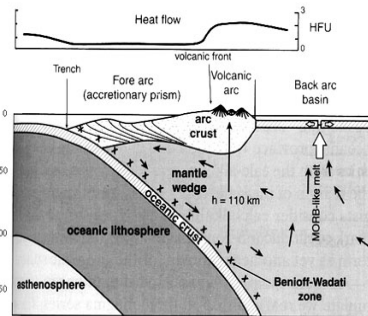
Batholiths

- An example: the Sierra Nevada Batholith, CA
- A group or groups of separately intruded plutons with a composite volume of 10^6 km^3
- Age extends through the Mesozoic ($>130 \text{ my}$)
- Average pluton volume is $\sim 30 \text{ km}^3$



Emplacement Process

- Stopping
- Brecciation
- Doming
- Ballooning
- Void zones



Stopping

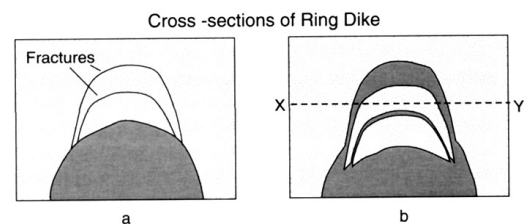
- Concentration of water near top of magma causes hydrofracturing
- Thermal stress and pressure fractures rock
- Fractured rocks engulfed by magma
- Incorporated blocks sink in the magma
- Magma moves upward occupying space
- Isotropic fabric

Xenoliths

- These features are evidence for stopping
- Blocks may become schlieren
- They also could assimilate in magma

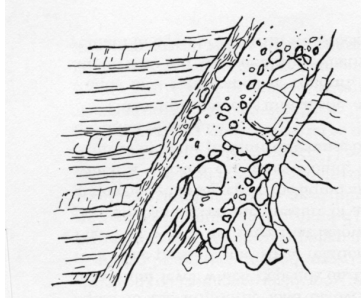
Ring Fracture Stopping

- Failure of the roof of a chamber
- Dikes form a ring around the sinking slab
- Magma also intrudes above the sinking block



Breccia Pipes

- Slender vertical pipe-like bodies of breccia
- Elliptical or circular cross sections

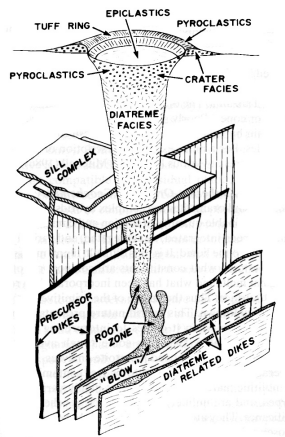


Dikes vs. Pipes

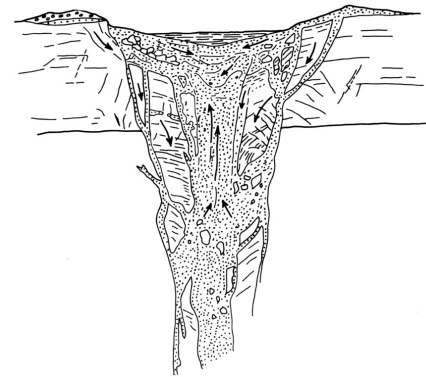
- Dikes grow by extensional fracturing
- Their conduit is the route of greatest magma volume for the existing pressure
- A dike requires the least work on the wall rocks to accommodate the volume of magma
- So why do we have pipes?

Diatremes

- Perhaps drilling is the answer?
- Diatremes formed by volatile (H₂O, CO₂) rich intrusions
- Crammed with xenoliths of country rock

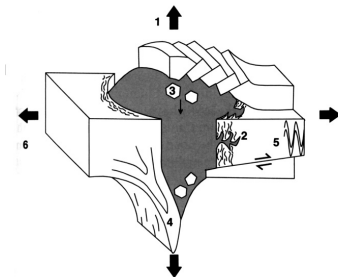


Diatreme and Vent



Doming

- Over-pressured magma may make a roof for itself
- This may form a laccolith
- Begin as sills and then inflate toward the surface



Ballooning

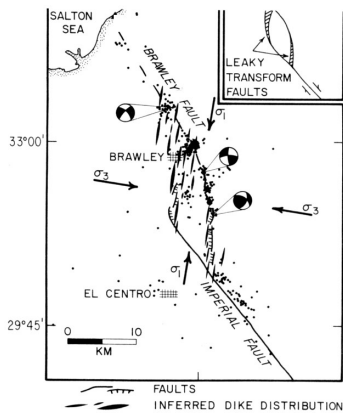
Radial directed inflation as magma intrudes

Evidence for ballooning:

- Circular outline of pluton
- Concentric foliation of pluton concordant with outer contacts
- Increased strain toward the contact
- Concentric compositional zoning

Tectonic Room

- Dilatant faults zones
- Bends in a fault zone
- Hinge zones of folds
- Domains of extension in a compressive regime



The Intrusion

- Contacts
 - Record length and type of effects
- Border zone
 - May be permeated with changes due to thermal, chemical, and deformational effects

Contacts

- Rapid cooling gives a sharp contact
- Strong thermal gradient produces weak contact effects
- Grain size may decrease toward the contact indicating rapid cooling
- Sharp with no change in grain size could indicate flowage past a chilled margin

Border Zone

- Large plutons commonly have a wide border zone
- Invasion of host by dike systems
- Evidence of stoping
- Partial melting of host
- Contact metamorphism

Timing of Intrusion

- Pre-tectonic
- Post-tectonic
- Syn-tectonic

Pre-tectonic Features

- Intra-pluton foliation parallels country rock foliation
- Foliation cuts across the contacts at a high angle

Post-tectonic Features

- Sharply discordant contacts between country rock and the pluton
- Foliation of mafic inclusions in the pluton are concordant with the contact

Syn-tectonic Features

- Pluton contact is subparallel and concordant with foliation in the country rock.
- Magmatic minerals have the same isotopic age as minerals that define the age of foliation in the country rock