# Chapter 1 : Nature of Geology

- observational science
- there are a lot mountains on the West coast

## how does geology influence where we live

- we live within a 50 mile radius of a large water body
- transportation
- need water to survive
- food (fishing)
- 1/3 of the entire food for the country comes out of the Central Valley
- nature likes to build things up and tear them down

Creatures tend to bundle where there is resource pool, be it water, food, shelter, energy, etc

## what is inside earth

- upper layer is the crust (two types):
  - continental
  - oceanic
- thickest layer
  - mantle
- deepest layer:
  - iron-nickel core (molten outer core, solid inner core)

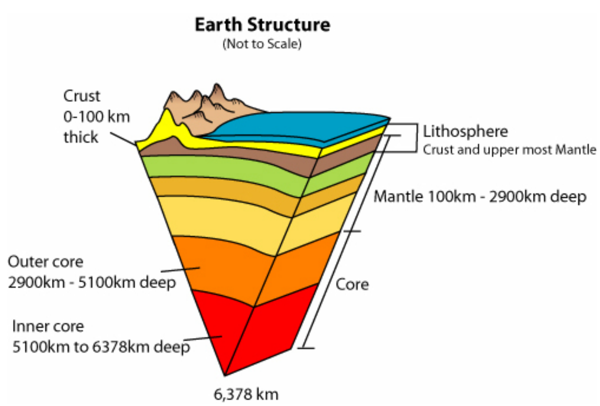


Figure 1: earth struct

### some layers are stronger than others

- The top layer of the Earth is stronger than the middle.
  - For example, a tootsie pop very dense on the outside and as you approach the center, it gets chewier.
- This external layer is called the lithosphere which contains (in order):
  - continental crust
  - oceanic crust
  - lithospheric mantle
- The inner layer is called the asthenosphere
  - it is hot, weak and mostly solid

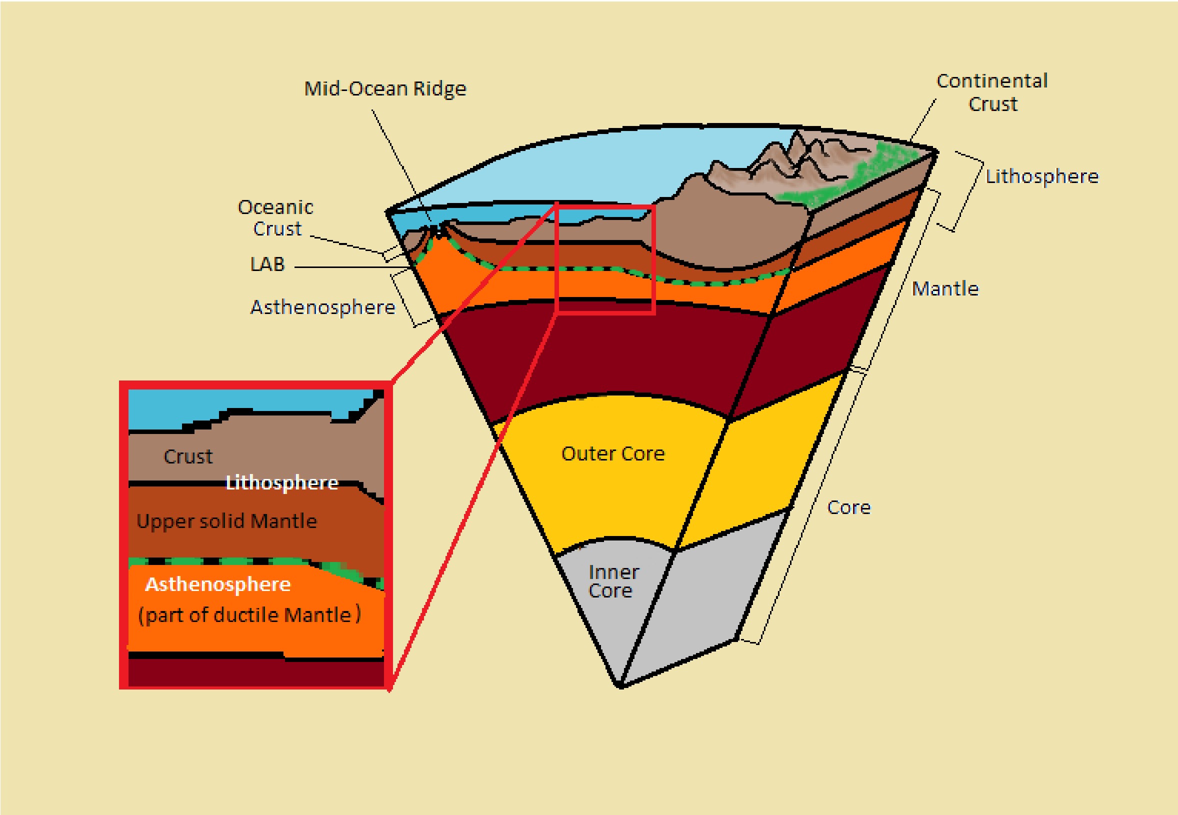


Figure 2: litho and asthen diagram

- Hot things want to rise
  - lava rises because it is less dense than the surrounding rock

Mountains get more precipitation because they are higher in elevation

- clouds get to the mountains first
- one side gets water and the other side gets nothing
- the wet side of the Andes allows for more life and the other side, Chile, its one of the driest places on earth

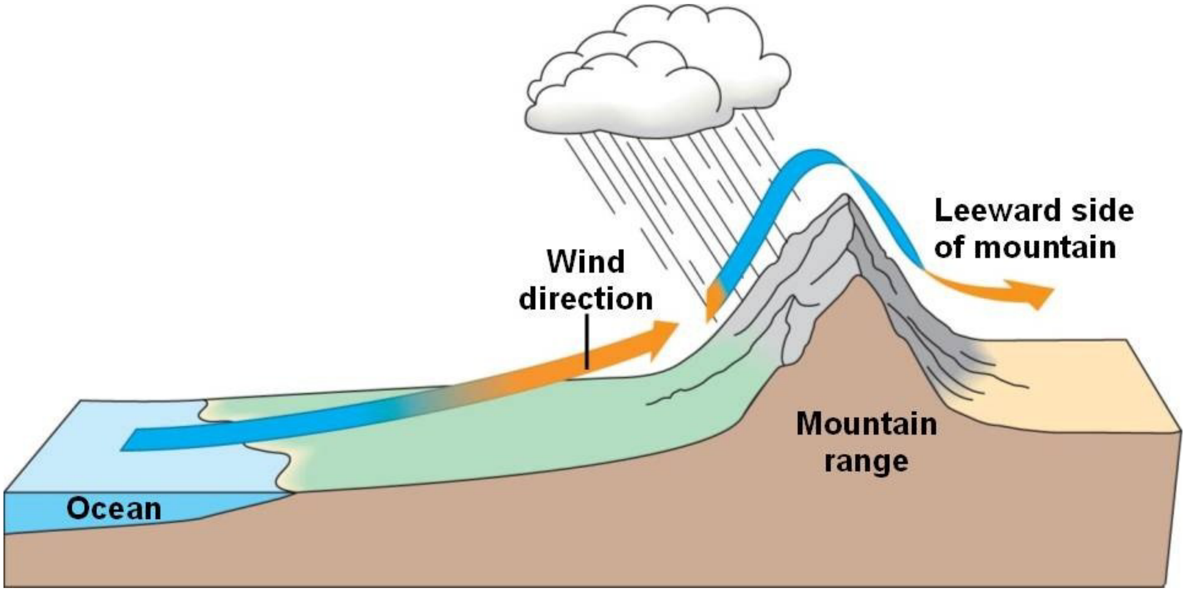


Figure 3: leeward mountain diagram

## why are some regions high in elevation

- areas that have a thick continental crust tend to be higher in elevation
- these areas also are thicker than the oceanic crust it neighbors
- Thick blocks are higher than the thinner blocks around them
- Thinner blocks are lower because they are more dense
- This relationship between crustal thickness and elevation: **isostasy**

### isostasy

Formal definition:

- the equilibrium that exists between parts of the earth's crust, which behaves as if it consists of blocks floating on the underlying mantle, rising if material (such as an ice cap) is removed and sinking if material is deposited.

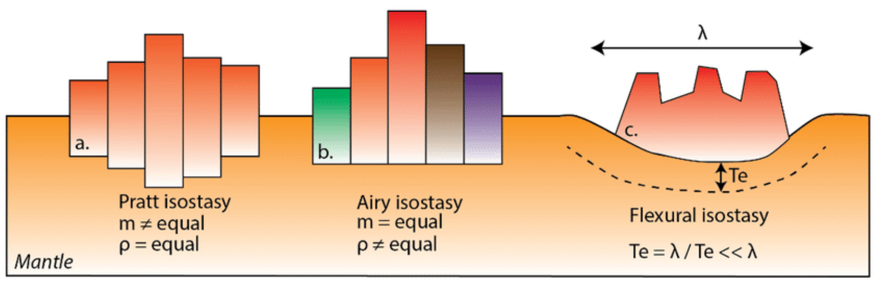


Figure 4: isostasy model

## earth's forces and how they help process it's materials

Many different environmental factors help shape the Earth such as atmospheric pressure, gravity, etc

## steep mountain front

- steep and angular
- have not moved far
- rocks -> sand grains

## rock formation

- **igneous** rocks (fire rocks)


Figure 5: fire rock

These rocks form from magma and are expelled by volcanoes

- **metamorphic** rock (rocks that have changed)


Figure 6: changing rock

These rocks can be found away from a volcano, more specifically rocks moved by nature. Sand is an example of this as grains of sand are actually microscopic balls of rock.

- **sedimentary** (rock layers)

Figure 7: layered rock

Layered slabs of rock where the bottom is older than the top. This is the only rock to support fossils, other rocks would erode or destroy fossils.

### rock cycle

The process in which rocks change between states and types.

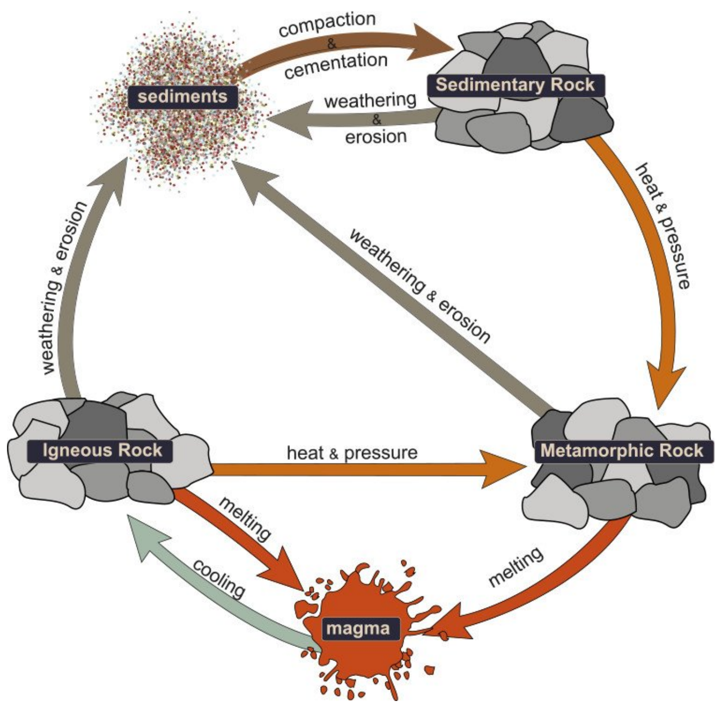


Figure 8: rock cycle

# Chapter 2 : Investigating Geologic Questions

## Things to look out for

- Observe the Mediterranean Sea, noting how it connects (or does not connect)
  - Human intervention
  - Plate tectonics allow for water to flow
- Draw what you see
- Different scales (perspectives) are different ways of viewing a scene
  - Earth from space vs microscope
- Compare this rock to deposits from two environments shown below
  - Which environment has deposits most similar to the rock
- uniformitarianism (rocks are being moved now and it can be assumed that they moved in the past)

## Interpreting Evolution of Landscapes

- rain, wind, erosion etc

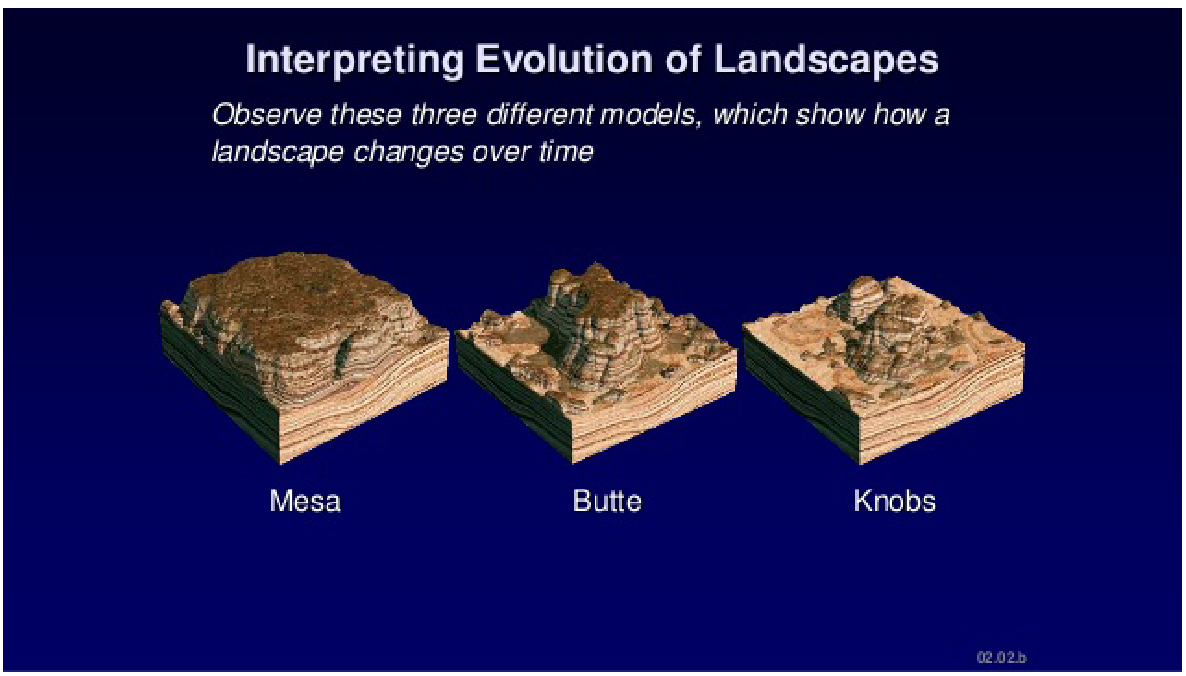


Figure 1: landscape transformation diagram

### Determining Sequences of Events: Position of Layers

The bottom most layer is the oldest in the stack

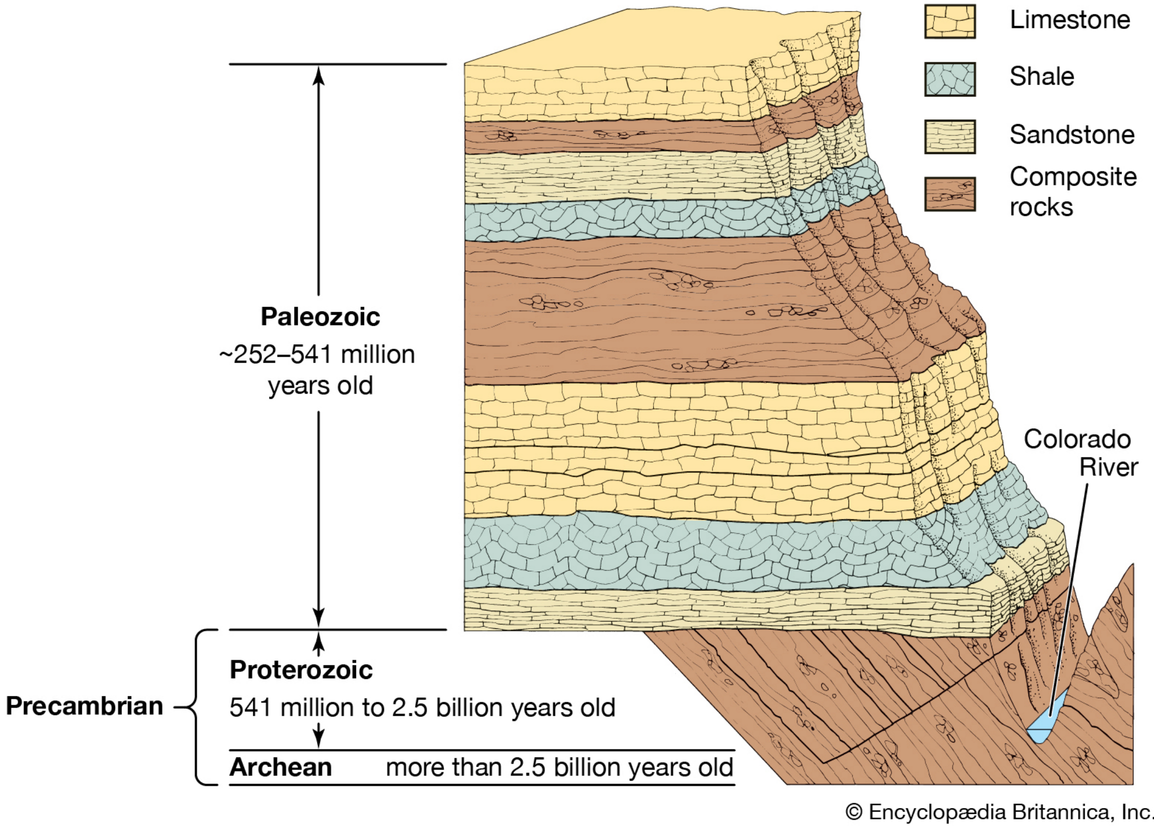


Figure 2: Positions of Layers

### Cross-Cutting Relations

Faults, fractures and cracks can only occur if the layers existed first

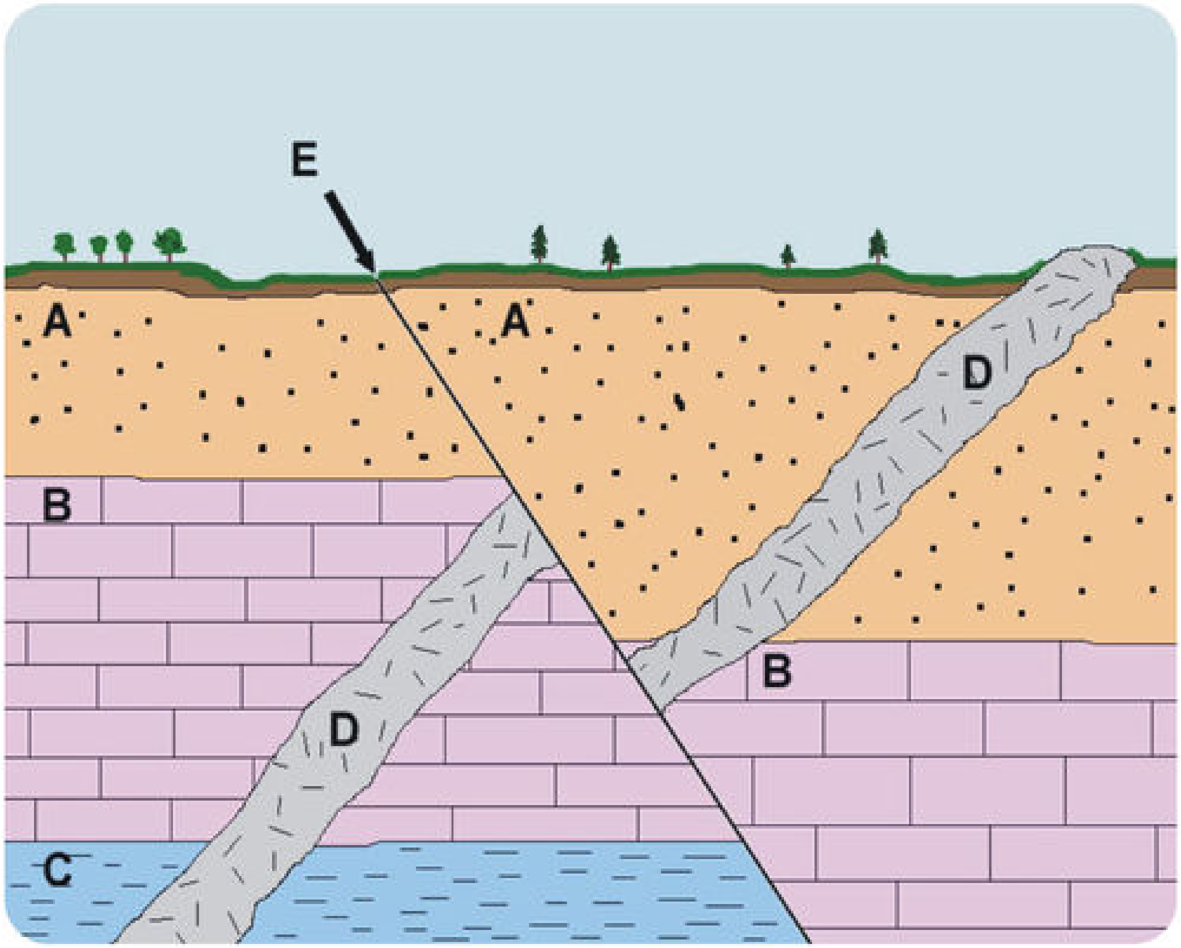


Figure 3: Cross-cutting relationship

## Pieces of clast

Older rock that is trapped inside newer rock

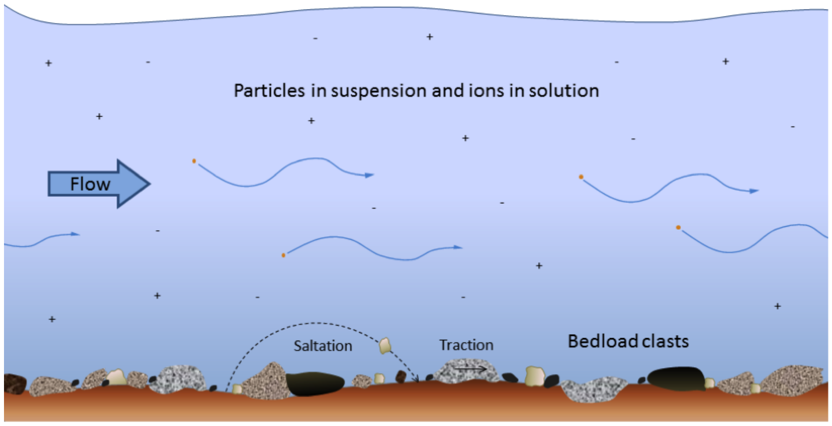


Figure 4: Clast found in an younger solution

## Contact Effects

Hot molten rock burns cooler surrounding rock. This is called the “Baked Zone”

Figure 5: Baked Rock Vein

**Rock layers can be different**

## Types of Maps

- Shaded-relief map
- Topographic map with elevation contours (change in gradient)

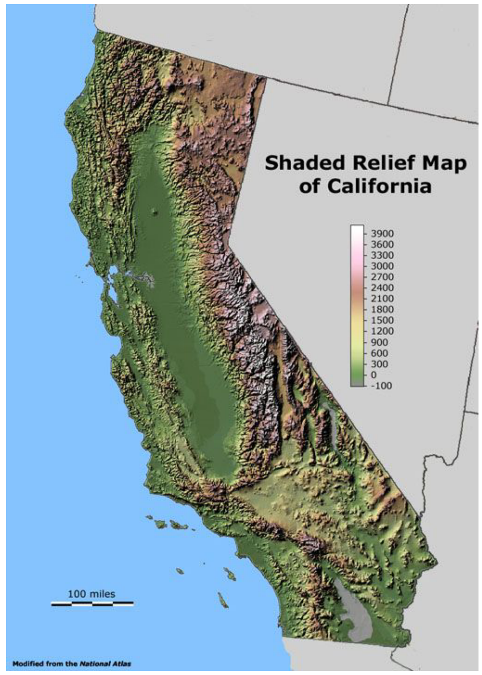


Figure 6: Shaded relief map of California

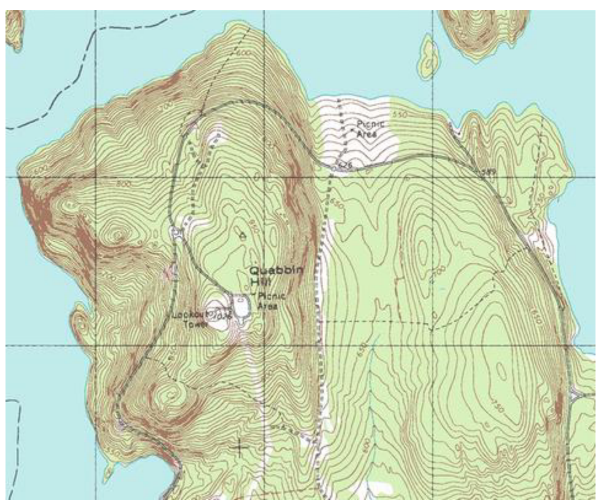


Figure 7: Topographic map of California

## Qualitative vs Quantitative

- Qualitative : descriptions
- Quantitative : numeric measurements (conveyed with numbers)

## Density

- Mass/Volume

## Weight

- Downward force an object exerts via gravity

# Chapter 3 : Plate Tectonics

There are many plate boundaries and they have unique characteristics

## Fossil Data and Continental Drift

- similar animals at boundaries between continents
- continents were all together at one time
- WW2 changed our perspective
- map where all the earthquakes happen, where all of the volcanoes were
- mountains in the belts

## Three Types of Relative Plate Motions

### Moving apart: divergent boundary (Atlantic ocean)

```
- magma is coming up from the bottom to fill the gap
-
```

### Moving toward each other : Convergent Boundary

```
- same density
- the plate begins to melt at some depth and forms a chain of islands
```

- move horizontally past one another: transform boundary (san andres fault)
  - zig-zag pattern and is not a linear path for the fault

## What moves the Plates

We are not sure what the root cause of the movement is

# Chapter 4 : Earth Minerals

- Solid
- Natural
- Inorganic
- Ordered internal structure
- Specific chemical composition

Figure 1: Examples of minerals

## Is ice a mineral

Ice by definition it is a mineral (when solid) but as a liquid is not.

Figure 2: Ice, ice, baby

## Mineral formation in other rocks

Composed of visible or microscopic crystals: crystalline rock

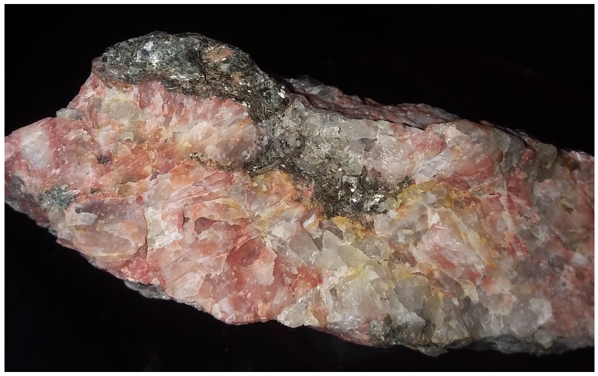

Figure 3: Crystalline Rocks

Composed of pieces (clasts): clastic rocks

Figure 4: Clastic Rock

## Distinguishing One Mineral from Another

### Crystal formation

### Cleavage

- How it shears along smooth planes parallel to the zones of weak bonding.
- Sheets joined by long bonds between sheets break along the weakest bonds
- Bonds with the same strength can break along `N` sets of planes without passing through an atom
- In other arrangements, the mineral will break in nearly any direction so it will fracture instead of cleave.

### Color

### Luster

How much it reflects in the light

### Hardness

How strong the bonds are between the atoms

### Effervescence

The foaming and fizzing reaction when certain chemicals come in contact with it

### Streak

What color does it leave behind if scraped on a porcelain plate

### Magnetism

Does it attract magnets

### Density

## What controls a crystal's shape

- Sizes and packing of atoms
- Internal structure of the mineral
- orderly arrangement of atoms in repeating patterns

### Different shapes

- Cube
- Tetrahedron
- Octahedron

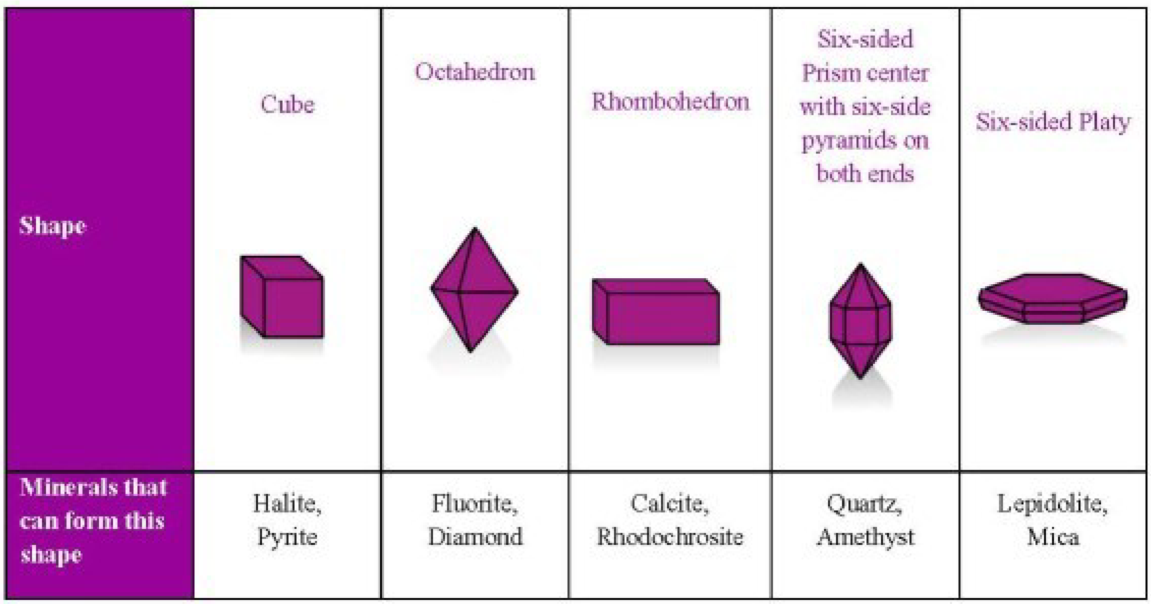


Figure 5: Crystal shape diagram

## Major Classes of Rock-Forming Minerals

### Silicate Minerals

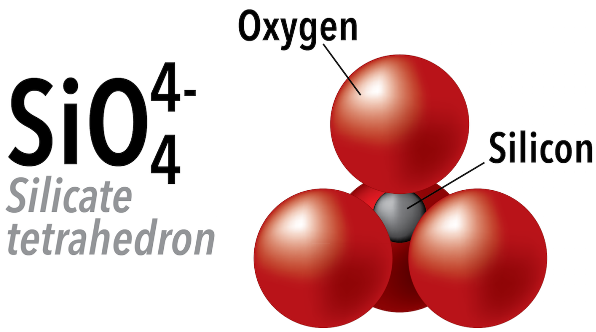


Figure 6: Silicate Tetrahedron

Can bond together and with other elements

#### Independent Tetrahedra

Tetrahedra bond to other elements, not other tetrahedra

Figure 7: Olivine

**Single Chain**

Figure 8: Pyroxene

**Double Chain**

Figure 9: Amphibole

**Sheet Silicate**

Figure 10: Mica

**Frameworks**

Figure 11: Quartz

**Nonsilicate Minerals**

**Carbonates**


Figure 12: Calcite

**Oxides**

Figure 13: Magnetite

### Sulfides

Figure 14: Pyrite

### Halides

Figure 15: Halite

**Sulfates**

Figure 16: Gypsum

## How Atoms Bond

### Sharing

Covalent bond

Example: water

### Loaning

Ionic bond

Example: salt

### Free flow

Metallic bond

Example: copper

### Stick together

Intermolecular bonds

Example: Oxygen and Hydrogen bond

## Crystal Structure and Bonds

- Carbon makes up both graphite and diamonds
- The only difference between the two is the bonds that make up the substance
- Diamonds have an extremely strong network of bonds

## Properties of Water

- Oxygen and hydrogen share electron
- Water molecules are polar
- Helps dissolve other compounds

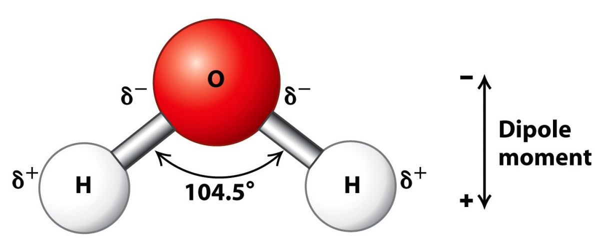


Figure 17: Water molecule diagram

# Chapter 5 : Igneous Environments

Must completely melt to become an igneous rock

## Characteristics

Depending on where it came from, it dictates what it looks like

Oceanic vs. Yellowstone

Volcanoes can have weak spots, not one single point in the mountain

### Textures

- Pegmatite : large individual crystals
- Coarse Grained :
- Medium grained :
- Fine grained
- Glassy
- Porphyritic
- Vesicular : trapped gasses inside the rock and floats (pumicis)
- Welded

High pressure, high heat rock wants to push its way up because hot things want to rise. The rate in which it cools is proportional to how fast it is coming up from the ground

Water plays a big role in volcanic rocks

## Felsic

- Granite
- Rhyolite

Takes a long time for this to break down

Cooling at the surface : extrusive (Rhyolite is volcanic ash) Cooling under the ground : intrusive

## Intermediate

- Diorite
- Andesite

## Mafic

- Gabbro
- Basalt

## Ultramafic

## Melting

Converting solid to liquid

You will get some new type of rocks when you do that

Temperature and pressure graph (insert here)

## Role of Source Area

Different viscosity (how easily it flows) - High : honey - Low : water

How much water is in the subsurface is important

Pillow basalts form when lava comes in contact with water directly

## Irregular Plutons

Small amount of exposed igneous rock

## Batholith

When giant igneous rocks were buried and now has been uplifted

## Dikes

Vertical cut

## Sill

Horizontal cut

Apache Tears

- Teardrop shaped obsidian

# Chapter 7 : Sedimentary Environments


Figure 1: Rocks have layers too

Exam will be 50-54 questions and the test is out of 100 points

Extra questions are delegated for extra credit

## Formation

They form at a low place - Depositional environment

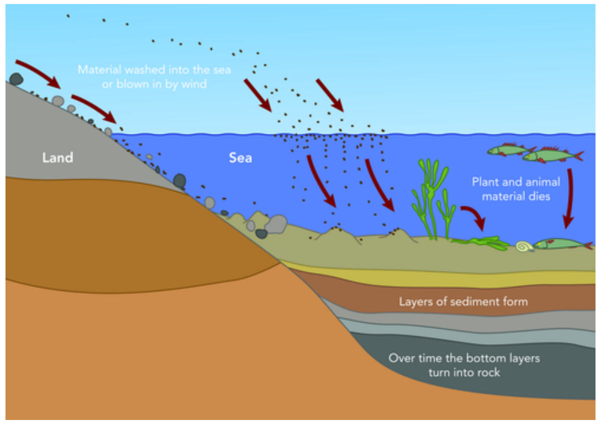


Figure 2: Sedimentary rock formation diagram

### Places

- Mountains
- Steep streams
- Sand dunes
- Slow moving rivers (Mississippi River)
- Deltas, wetlands (places where coal forms)
- Lakes
- Beaches
- Reefs
- Lagoons
- Beach dunes
- Tidal flats

## Physical Weathering

- Fracturing and crack rocks
- Frost and mineral weathering
  - (Ice expands when it freezes)
  - Sugar at the bottom of tea when there is too much sugar to be in solution
- Thermal expansion
- Roots and other biological activity


Figure 3: Goblin State Park

## Chemical Weathering

- Dissolution
  - Water is slightly acidic (anything with pH of 7 and below)
- Hydrolysis
  - the chemical breakdown of a compound due to reaction with water
- Oxidation
- Biological reactions
  - Plants will poison other plants to prevent them to get their resources
  - Animals will dig and dig

## Clast Sizes

- Boulders, cobbles, pebbles

### Shape

- Rounder == more distance traveled
- Angular == freshly broken

### Sorted

- Poorly sorted (fairly grade)
  - assorted sizes of clast
- Moderately sorted (moderate)
  - mostly the same size of clast
- Well sorted (poorly graded)
  - nearly all the same size

### Controls on size, shape, and sorting

- Steepness of slope
- Strength of current
- Agent of transport

### Common Clastic Sedimentary Rocks

- Conglomerate (Coarsest)
- Breccia
- Sandstone
- Shale (Finest)

### How Clastic Sediments Becomes rock

- Compaction (Stuff on top of it)
- Cementation (Sand + Lime = Cement)

### Rocks Formed by Chemical Reactions

- Setting → Rock salt
- Setting → Travertine (limestone)
- Setting (Coral reef) → Limestone with fossils
- Setting (Plant matter) → COal

### Other nonclastic sedimentary rocks

- Gypsum
- Chalk
- Dolostone
- Chert

### Types of bedding

- Parallel bedding

Figure 4: Parallel Bedding Example

- Cross bedding
- Graded bedding

### Characteristics of Breccia

- With rocky matrix
- Without rocky matrix

### Environments of Formation

# Deformation and Metamorphism

## Exam 1 Answers

1. b 2. a 3. b 4. c 5. a 6. c 7. a 8. b 9. a 10. a 11. b 12. c 13. a 14. b 15. b 16. b 17. d 18. e 19. d 20. a 21. c 22. c 23. d 24. e 25. c 26. c 27. e 28. c 29. b 30. b 31. d 32. e 33. a 34. d 35. c 36. e 37. d 38. d 39. a 40. e 41. a 42. e 43. b 44. a 45. e 46. d 47. a 48. c 49. b 50. a 51. c 52. b

## Making Metamorphic Rocks

### Strength of Rock

- Too much stress = failure
- more heat means more ductile

### How rocks respons to force and stress

- small amount of stress → block remains unchanged
- compression, shear, tension
- shallow levels: rocks fracture
  - earthquakes
- deeper levels: rock flows

## Types of Fractures

- joint: small
  - burial
  - cooling and contraction
  - unloading
- fault: big (rocks have slipped past one another)
  - left lateral: block on opposite side moves to left

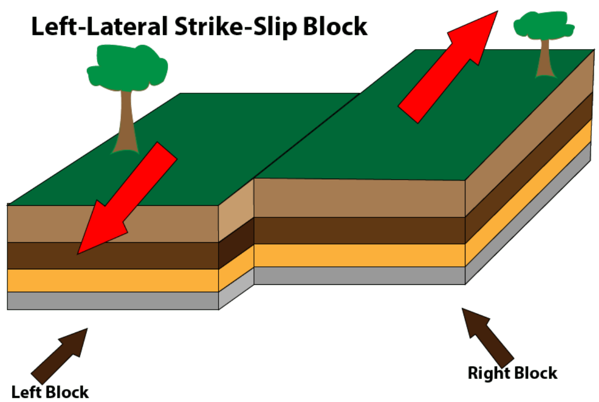


Figure 1: Left lateral

```
- right lateral: block on opposite side moves to right
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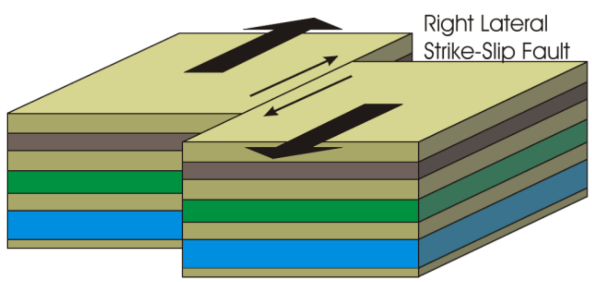


Figure 2: Right lateral

- anticline: up
- syncline: down

# Contents

# Chapter 9 : Geologic Time

## Some header