

# 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)

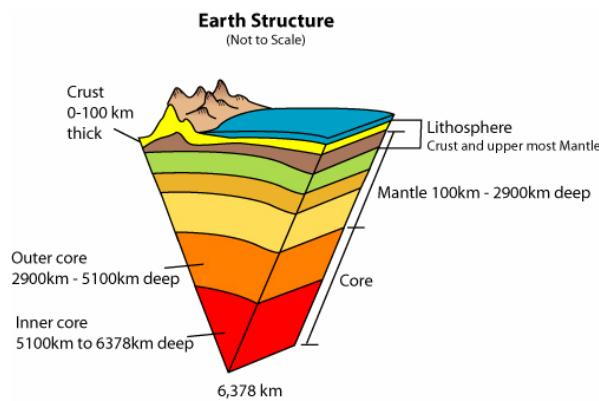


Figure 1: earth struct

## 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

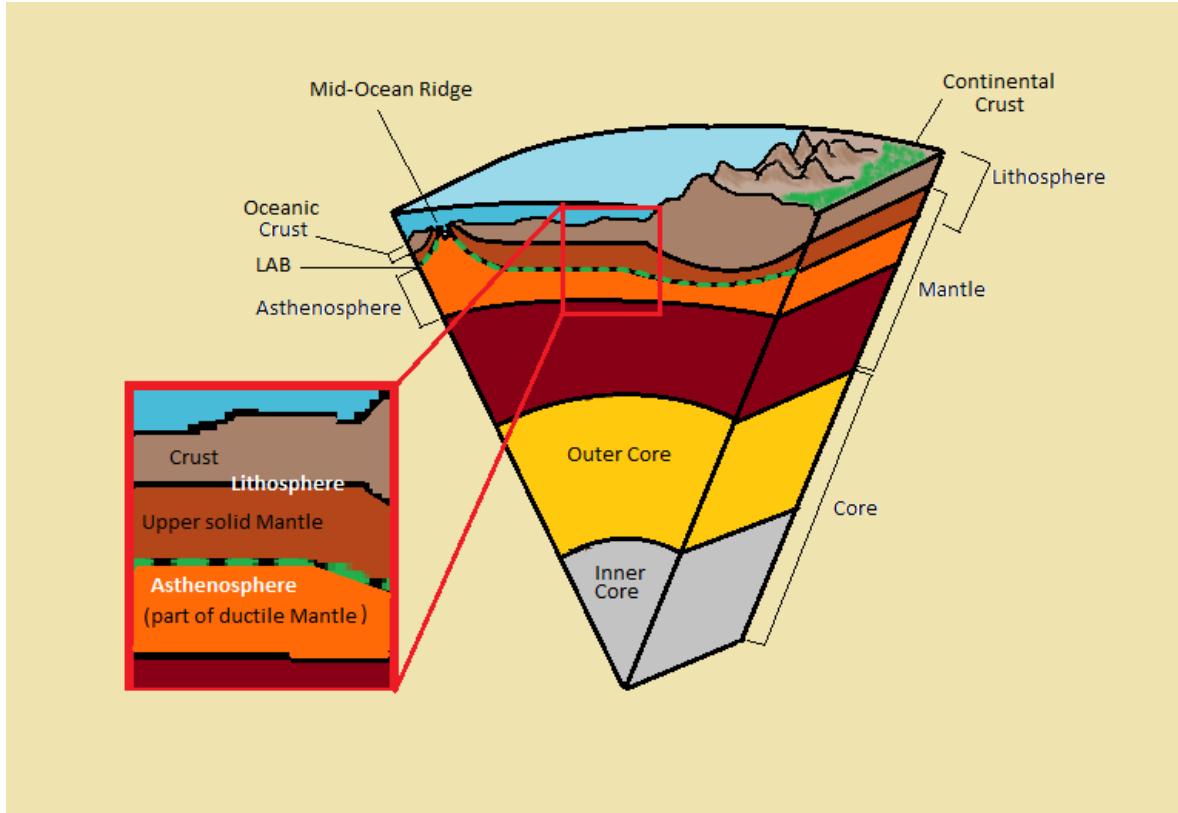


Figure 2: litho and asthen diagram

- 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

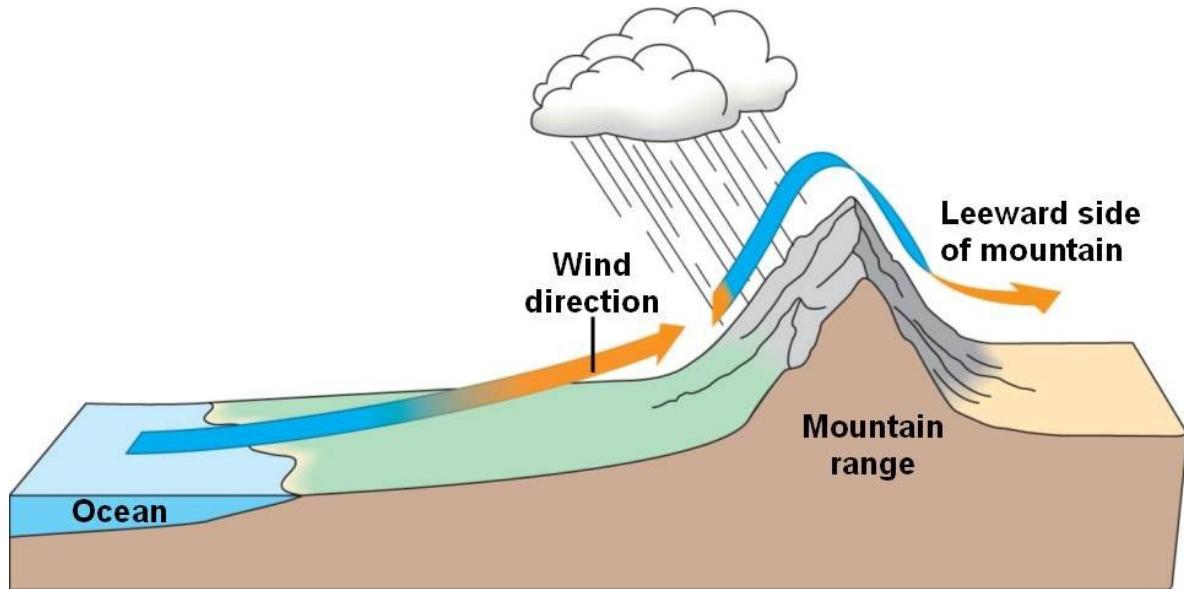


Figure 3: leeward mountain diagram

## 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.

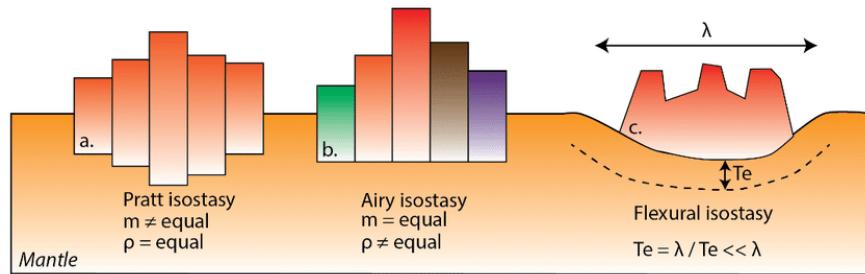


Figure 4: isostasy model

## 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.

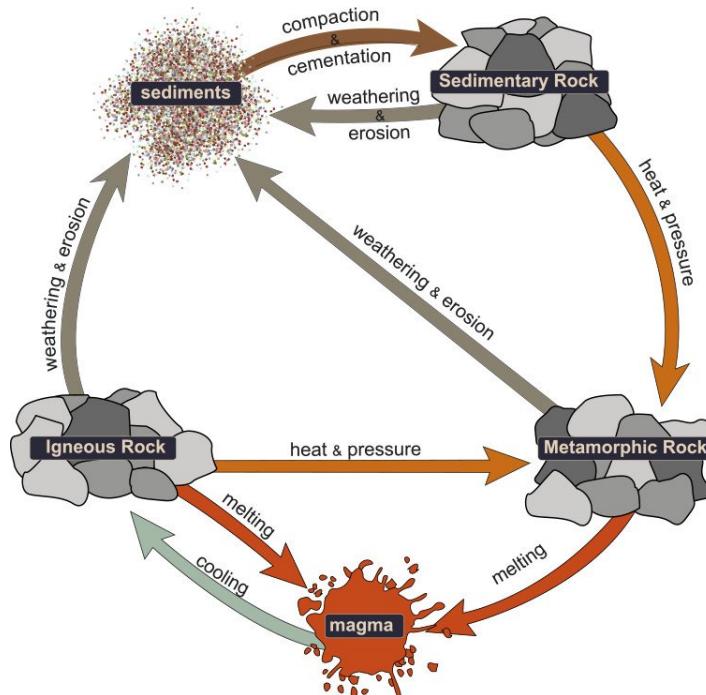


Figure 8: rock cycle

## 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

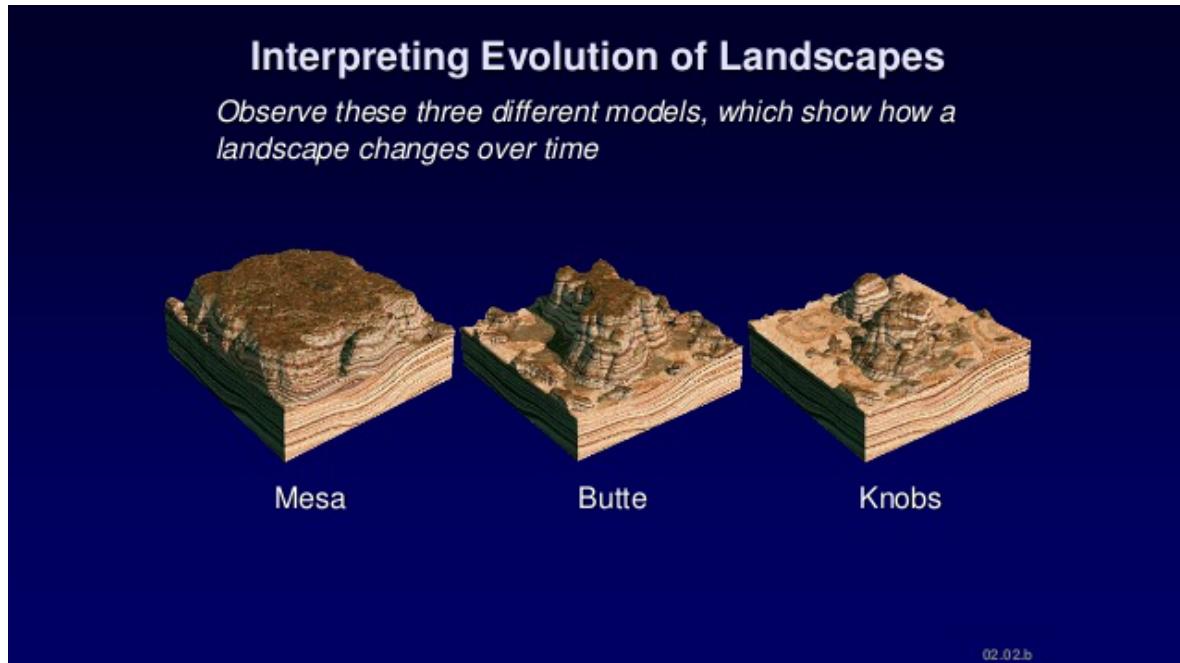


Figure 1: landscape transformation diagram

## 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

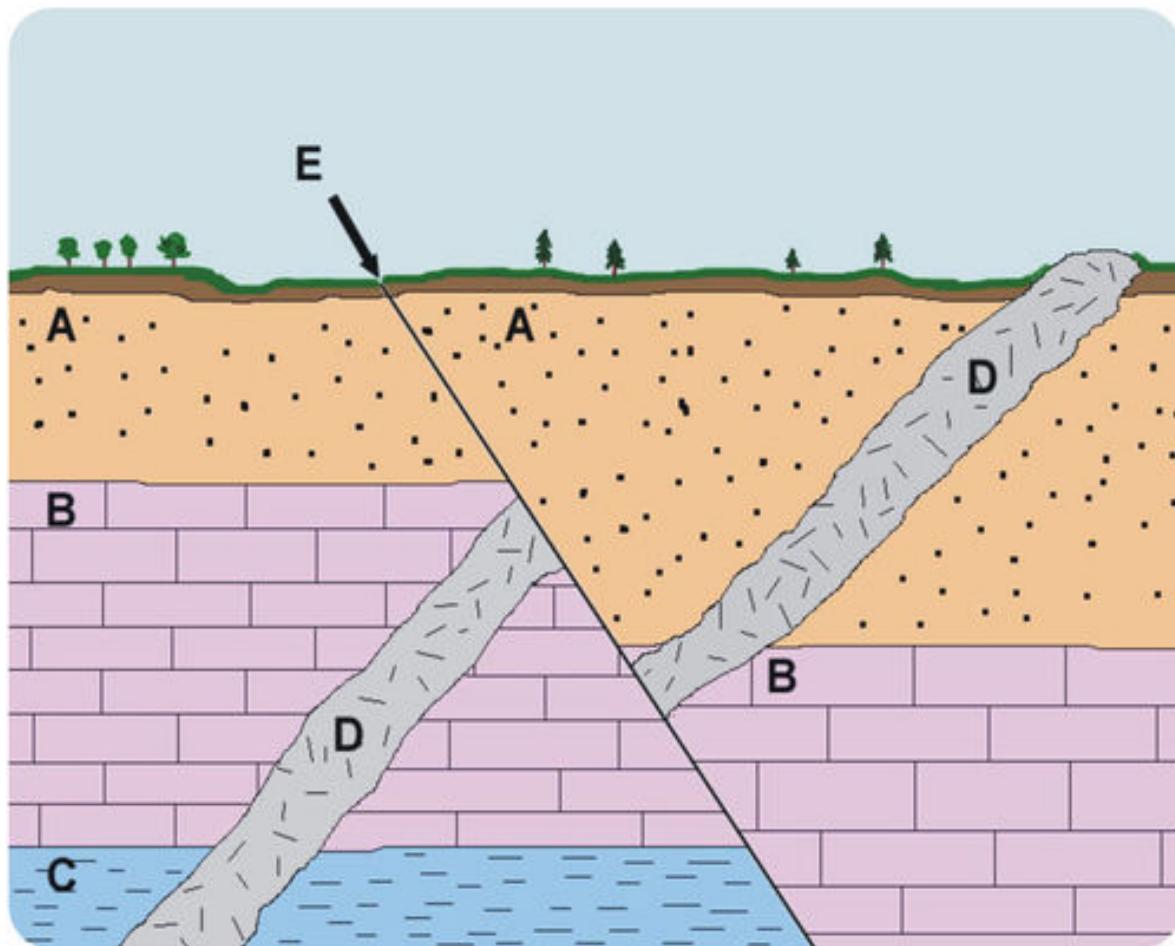


Figure 3: Cross-cutting relationship

## Pieces of clast

Older rock that is trapped inside newer rock

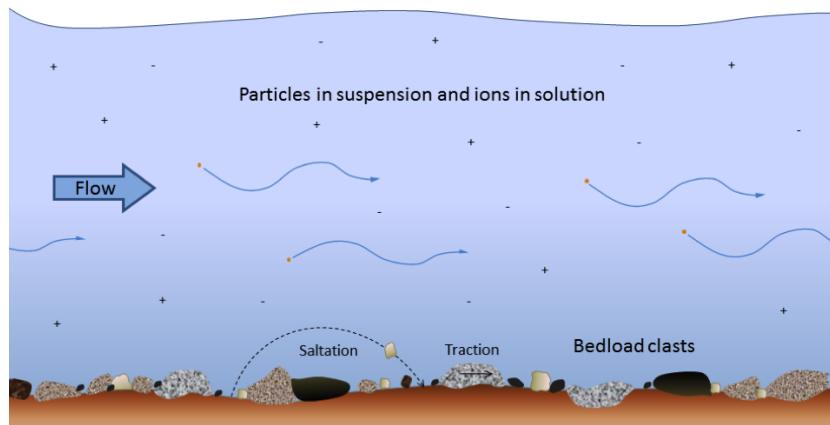


Figure 4: Clast found in an younger solution

## 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

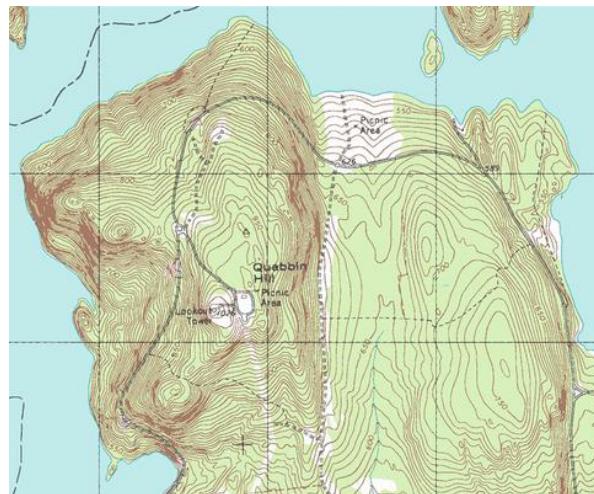


Figure 7: Topographic map of California

## **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

<b>Shape</b>	Cube	Octahedron	Rhombohedron	Six-sided Prism center with six-side pyramids on both ends	Six-sided Platy
<b>Minerals that can form this shape</b>	Halite, Pyrite	Fluorite, Diamond	Calcite, Rhodochrosite	Quartz, Amethyst	Lepidolite, Mica

Figure 5: Crystal shape diagram

## Major Classes of Rock-Forming Minerals

### Silicate Minerals

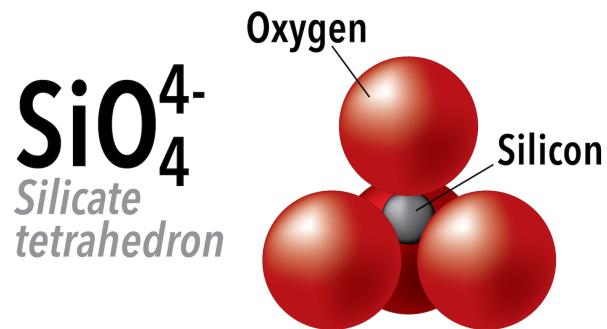


Figure 6: Silicate Tetrahedron

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



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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

## 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

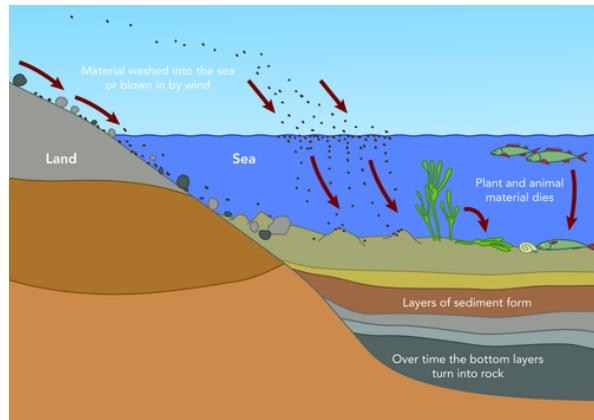


Figure 2: Sedimentary rock formation diagram

## 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

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## 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.<br>b 12. c 13. a 14. b 15. b 16. b 17. d 18. e 19. d 20. | 27. e 28. c 29. b 30. b 31. d 32. e 33. a 34. d 35. c<br>36. e 37. d 38. d 39. a 40. e 41. a 42. e 43. b 44. a<br>45. e 46. d 47. a 48. c 49. b 50. a 51. c 52. b |
|---|---|

# Making Metamorphic Rocks

## Different Kinds of Stress

- **Confining pressure:** same amount of stress from all directions
- **Differential stress:** different amounts of stresses from different directions.

## Strength of Rock

- Too much stress = failure
- ↑ heat ↑ ductile
- different material respond differently
- rock is more sturdy than wood, so it can support more force

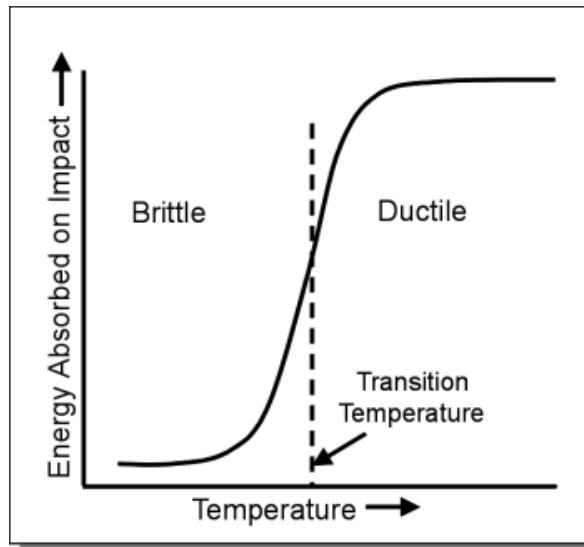


Figure 1: Brittle to Ductile Transition

## How rocks responds to force and stress

- small amount of stress → block remains unchanged
- examples of stresses → compression, shear, tension
- shallow levels: rocks fracture
- these rocks are generally weaker
  - earthquakes
- minerals are usually static/unchanged
- deeper levels: rock flows (heat and pressure)
- become more like play-doh
- minerals will recrystallize and may expand

## Types of Fractures

### Joint: small

- where rocks are pulled apart
- burial
- cooling and contraction
- unloading

### Fault: big

- rocks have slipped past one another

left lateral: block on opposite side moves to left

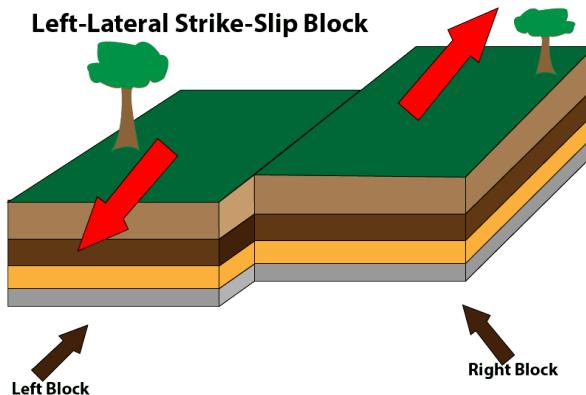


Figure 2: Left lateral

right lateral: block on opposite side moves to right

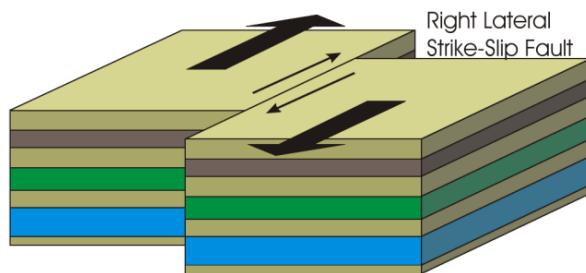


Figure 3: Right lateral

anticline: up

syncline: down

## Describing Faults

- Strike-slip: when two plate slide by each other from left to right
- Dip-slip: when two plates slide by each other from top to bottom
- Oblique-slip: when two directions of displacement occur. One side is higher than the other.

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## **Chapter 9 : Geologic Time**

Some header

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## Climate Change

- weather can change very drastically
- weather and climate can change across small distances

## Air Pressure

- move from high to low
- force exerted by the air above us
  - more air pressure at lower elevation (closer together)
  - less air pressure at higher elevation (farther apart)
- \* An example of this is Denver, Colorado. Sporting events played at this location notice farther ball travel and that is because it is a mile above sea level. This makes the air thinner as there is less of it.
- things want to move towards sea level (equilibrium)
- air is wanting to move perpendicularly to isobars
- The change from high pressure to low pressure cause the formation of wind.
- Gas molecules at higher elevations tend to spread out.
- Air pressure reacts laterally

## Local Winds along Coasts

- rocks are not good capacitors to heat
  - they will be really warm in the morning and afternoon but quickly cool at nighttime.
- air will sink in colder zones (the water during the day) and rise when hot (the ground during the day)
  - this cycle is actually swapped during the nighttime because water can retain its heat much better than air can
- there are wind patterns globally
- prevailing westerlies (winds from the West)
- prevailing easterlies (winds from the East)
- the earth is always moving

## The Coriolis Effect

- an effect whereby a mass moving in a rotating system experiences a force (the Coriolis force) acting perpendicular to the direction of motion and to the axis of rotation.
- On the earth, the effect tends to deflect moving objects to the right in the northern hemisphere and to the left in the southern and is important in the formation of cyclonic weather systems.
- Affects anything moving in the air
- slow moving objects are more subject to this effect rather than fast moving objects
- since an object is on a moving sphere, the expected trajectory of the object will not be the actual trajectory when launched across a large distance. The ground is moving at a constant rate when the projectile is in the air.

## Three Phases of Water

- Solid (heat ↓)
- Liquid (heat is neutral)
- Gas (heat ↑)

Unique to Earth and makes it possible for life to exist

## Perception

- Heat it up and have it condensate into a liquid

Liquid → gas → liquid

## Condensation nuclei

- dust
- pollution
- salt

Things that water binds to in the atmosphere and creates rain drops

Most of our rain drops start off as ice, it heats up and creates rain drops

Mountains are high and the heavy clouds cannot make it over the mountain. They rain on us and then they are able to make it over the mountain

This is called the “rain shadow desert.”

## Cold Front

Cold mass encounters a hot mass and causes the hot mass to rise even more.

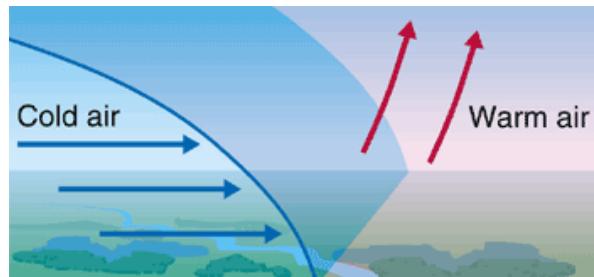


Figure 1: Cold Front

## Thermohaline Conveyor

- global circulation of surface and deep water driven by .....



Figure 2: Thermohaline Conveyor

## Large Weather Patterns

### Hurricanes

- northern hemisphere rotates counter-clockwise
- southern hemisphere rotate clockwise
- They are fighting the Coriolis Effect which makes it peter out
- These storms form in the middle of a warm ocean waters because they water will rise.
  - This water then fuels the large moving system and will eventually die if it reaches cold water or land, depriving its source of warm water
- Water in the equator is warmer and there is more rainfall/precipitation

### Tornadoes

- Tornadoes start over land
- These tend to move faster because there is more moving air condensed into a smaller area
  - Think of an ice skater tucking in to increase it's speed
- Tornado alley is right in the Mid-West.

### El Nino

- really warm and wet weather

### La Nina

- really dry and no rain

Faster the air means more things it can move.

## Global Climate Variability

The new name to global warming. There are a lot of different competing viewpoints on factors that contribute to the rise in carbon and the resulting heating up of the Earth.

There is no one solution/answer to how this will be fixed and if it is even entirely our fault. The Earth will go through cycles of cooling and heating. This is shown in the geologic time scale and we have no idea when or how much the Earth will change in temperature at a given time frame.

All we can do is to accommodate for the current situation and hope that our efforts make a difference.

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## Characteristics of a Glacier

- slow moving river
- moves rocks
- erosion and transport
- works its way down
- can merge together
- does not have to be in the mountains but has to be really cold and enough precipitation

## Glaciers in the Landscape

- cracks (crevasses) due to flow
- lower parts typically blue ice
- Fed by ice sheets or snowfields
- carry rocks, especially along margins

## Types of Glaciers

### Valley

- carve out and reshape the landscape

### Ice Sheet

Dunno what to put here

### Piedmont

- sit on top of the mountain

## Locations

- Antarctica
- New Zealand
- Iceland

## How snow accumulate

- since the material does not melt, there is continually compacted with layers upon layers
- glaciers form where accumulatation of snow and ice exceeds loss
- glaciers lose ice and snow by melting, wind erosion and sublimation
- equilibrium line: that divides the zone of ablation from the accumulation zone
- always dragging down the valley
  - cycle repeats itself

## Glacier Erosion

- Carries rock and other debris that can erodes underlying materials
- abrade and smooth off bedrock in the way
- pluck rocks from down-flow side
- striations (direction of movement of the glacier)

## Deposits of Glacial Origins

- Moraine (large pile of dirt, bulldozer went through and went home)
- Outwash
- Till (big clay ridge)
- Glacialfluvial Deposits

## Features Formed by Glacial Erosion

- Cirques
- Aretes
- U-Shaped Valley
- Fjord (tied to oceans)
- Hanging Valley

## Landscape Features of Continental Ice Sheets

- Kettle lakes (stick ice in a sand hole and cover it. What do you end up with?)
- Esker (river like)
- Drumlins

*add graphic here*

## Axis of Rotation

- More tilt:  $\phi = 24.5$
- Present tilt:  $\phi = 25$

## Shorelines

- Where water meets land
- Less water in the glaciers, more water in the ocean

## Characteristics

- Low tide
- High tide
- Waves
- Wind

## What are tides

- Pull of the moon
- there is a bulge when being pulled by the moon
- California has four tides and Florida has two

## Waves

- response of energy going through the water
- not going anywhere
- wave base =  $\frac{\Delta \text{crest}}{2} = \frac{\text{crest}_f - \text{crest}_i}{2}$