GG101 Final Exam Review

- Final Exam info:
  - Tuesday, December 15th   12-2pm
  - 100 multiple choice/true-false questions
  - Covers material from all lectures (comprehensive)
  - 1 hand-written page “cheat sheet” allowed (double-sided ok)
  - Things to help you study:
    1. Lecture notes (posted on web)
    2. Old midterms and practice exams (posted on web)
    3. Homework assignment questions
    4. Assigned reading

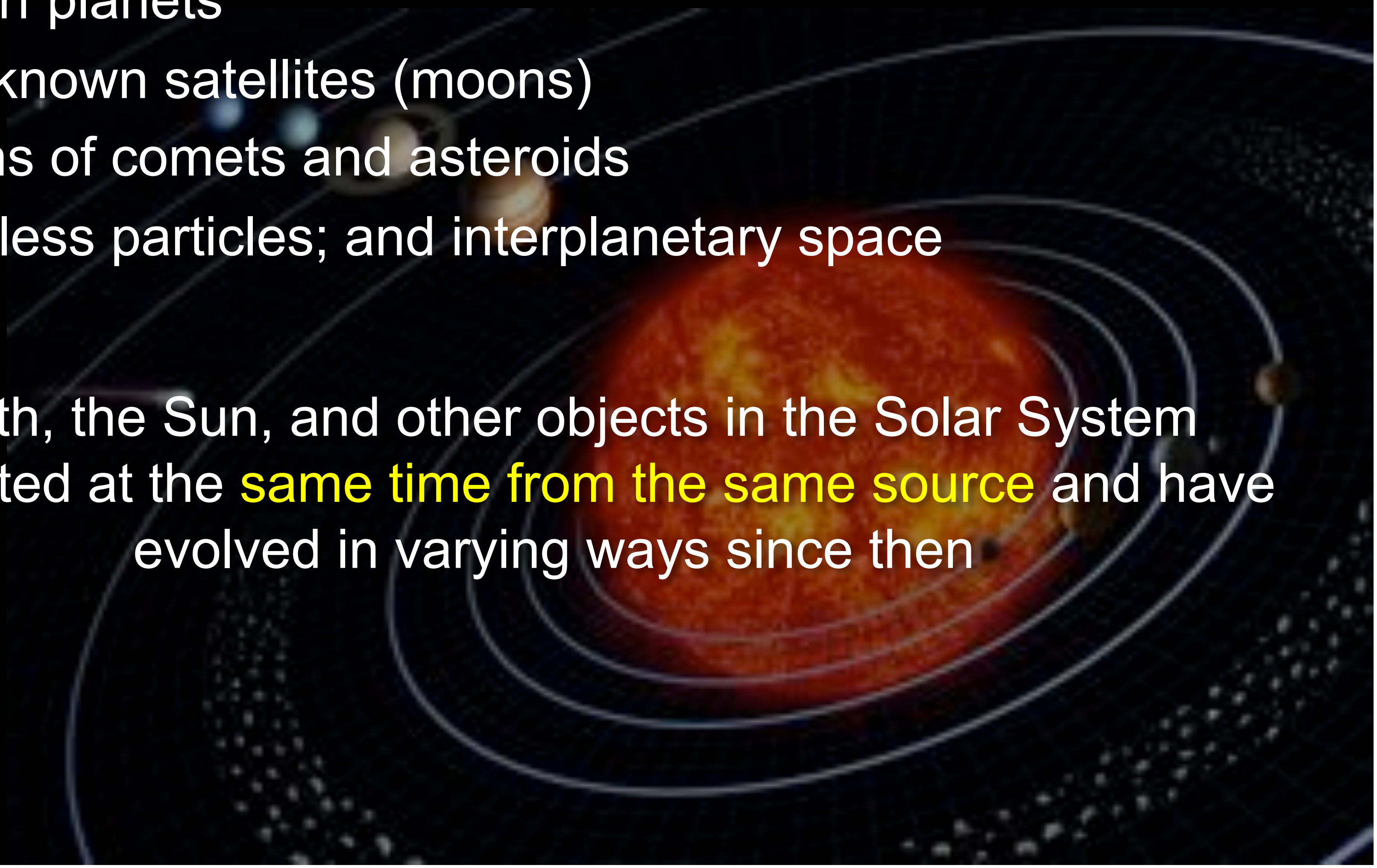
Class Website

http://www.soest.hawaii.edu/GG/FACULTY/smithkonter/GG_101/

Our Solar System Consists Of:

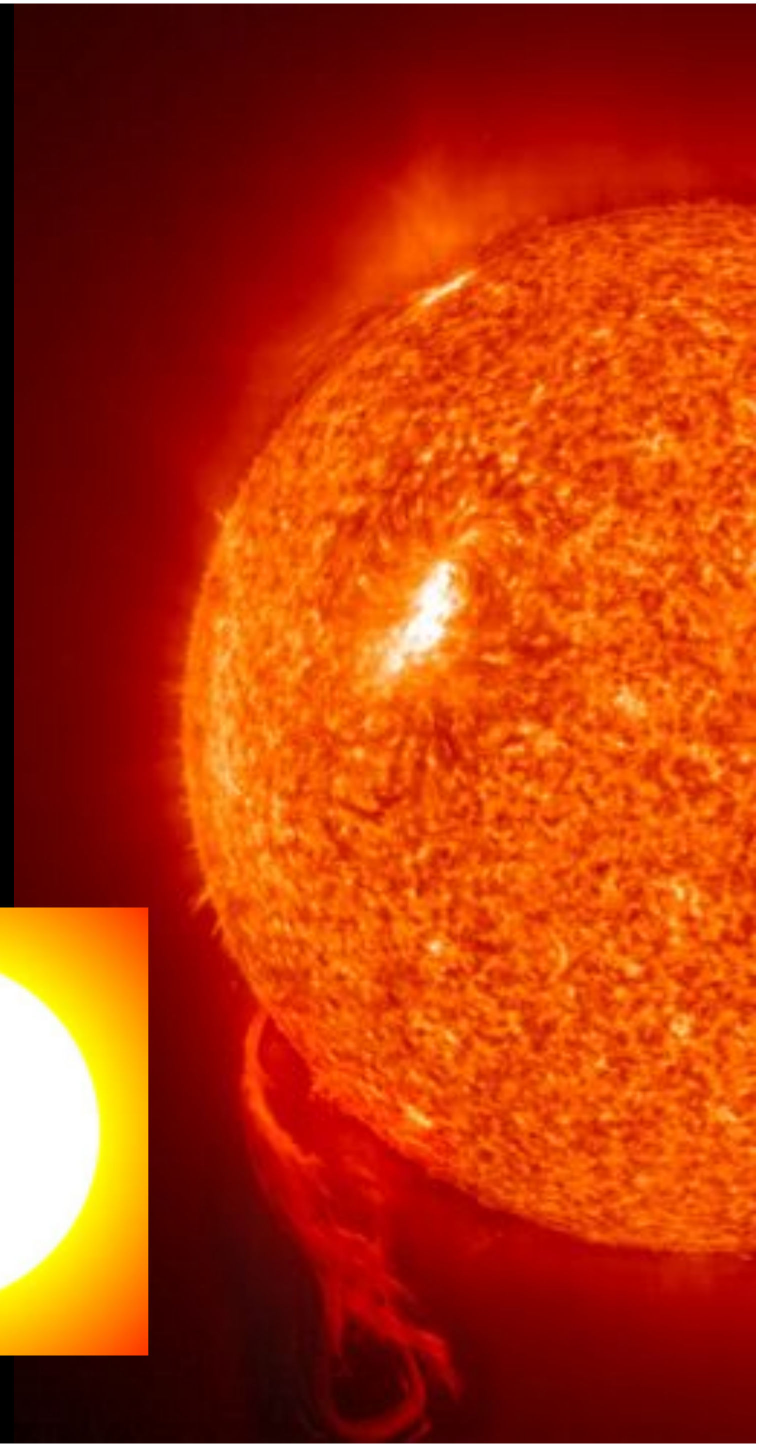
- 1 unordinary star
- 8 classical planets
- 5 dwarf planets
- 240+ known satellites (moons)
- Millions of comets and asteroids
- Countless particles; and interplanetary space

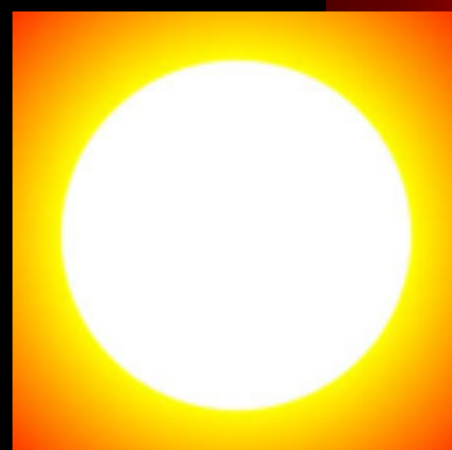
Earth, the Sun, and other objects in the Solar System originated at the same time from the same source and have evolved in varying ways since then



Our Sun

- Solar core is site of **nuclear fusion.**
- H is converted to He, which has less mass.
- Mass differential is expelled as energy (light and heat).
- The Sun is getting "lighter" through time.
- The Sun has enough fuel to last another 4 to 5 billion years.





Terrestrial Planets

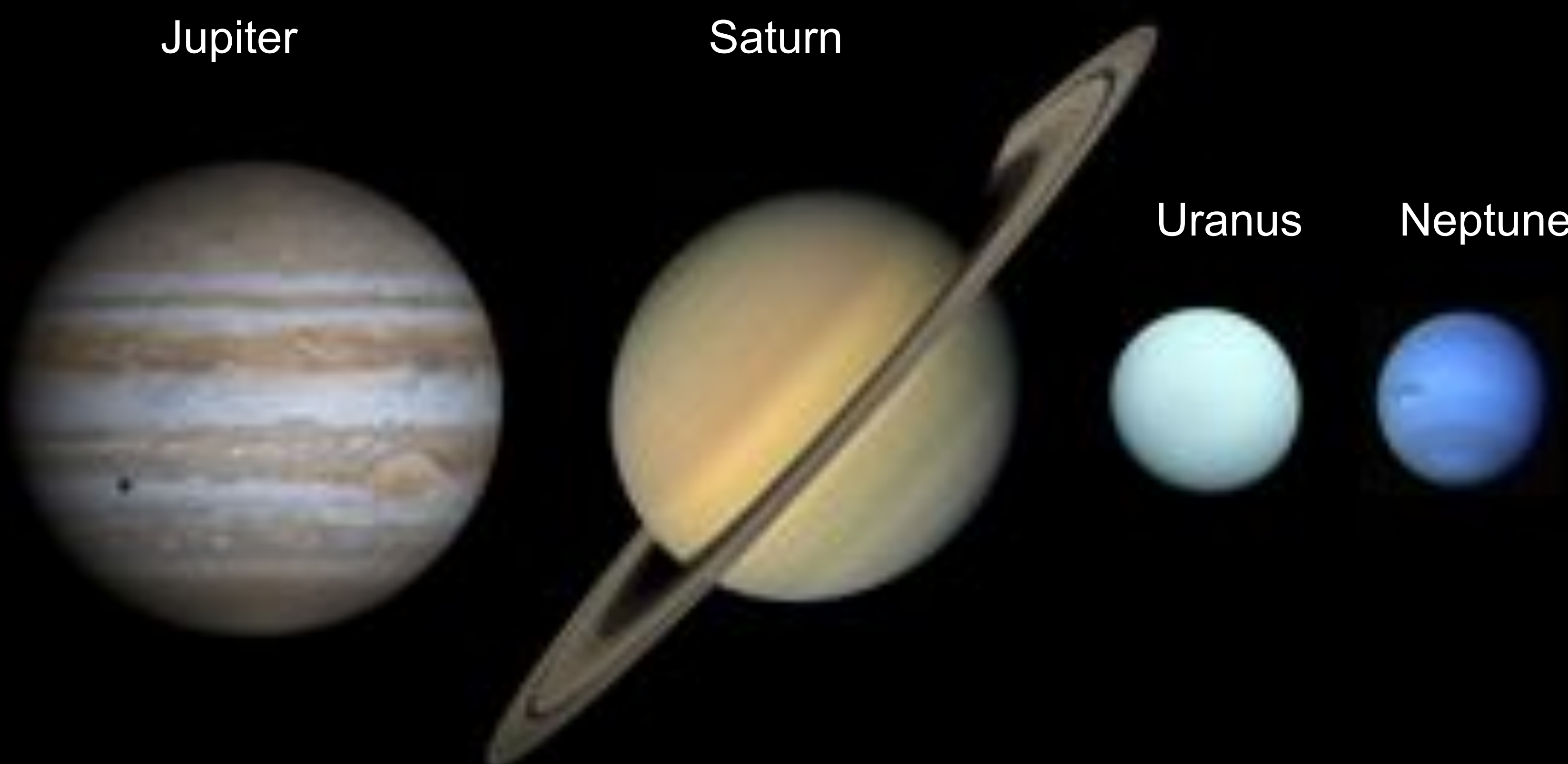
Terrestrial planets are small and rocky, with thin atmospheres, silicate & metallic shells.

Main components: O, Fe, Si, Mg, Ca, K, Na, Al

Gas Giant Planets

Gas Giant planets are massive with thick atmospheres.

Main components: He, H, CO_2, H_2O, N_2, NH_3, CH_4



Early Heat Within The Earth

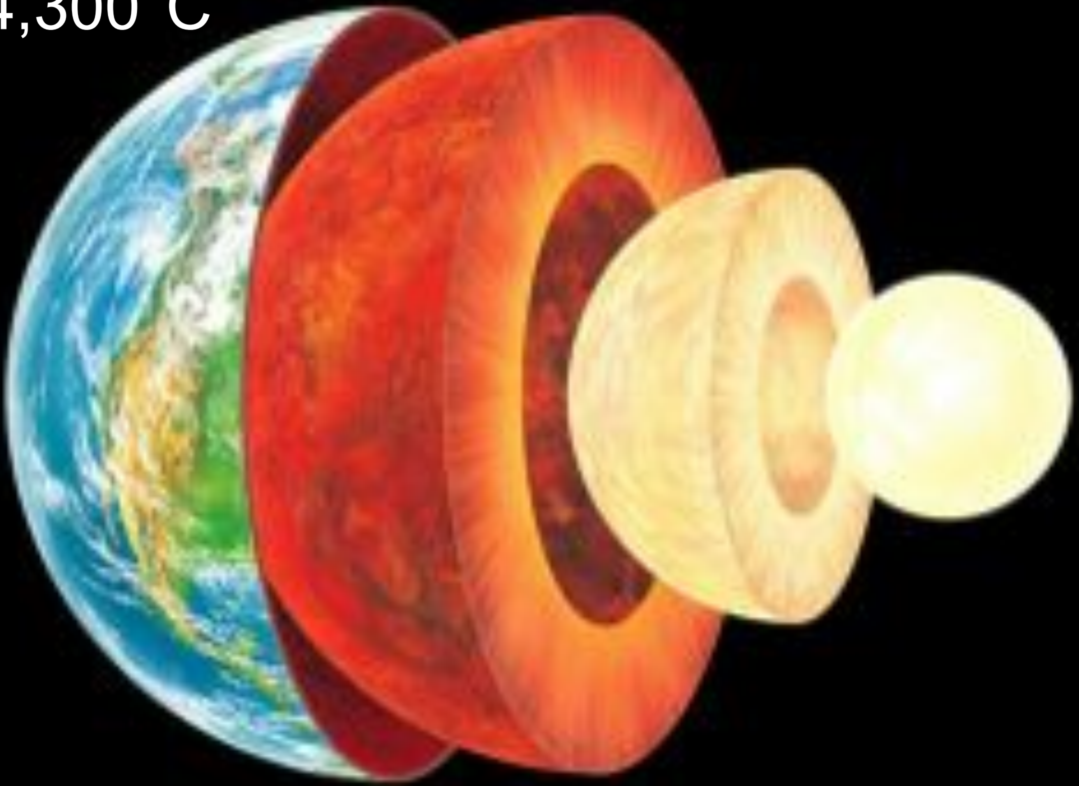
Early Earth began to heat as the last collisions subsided

1. Initial heat from impacts (bombardment)
2. Collisions produced heat that was stored (rock good insulator)
3. Radioactivity
4. Gravitational contraction

Earth's Core

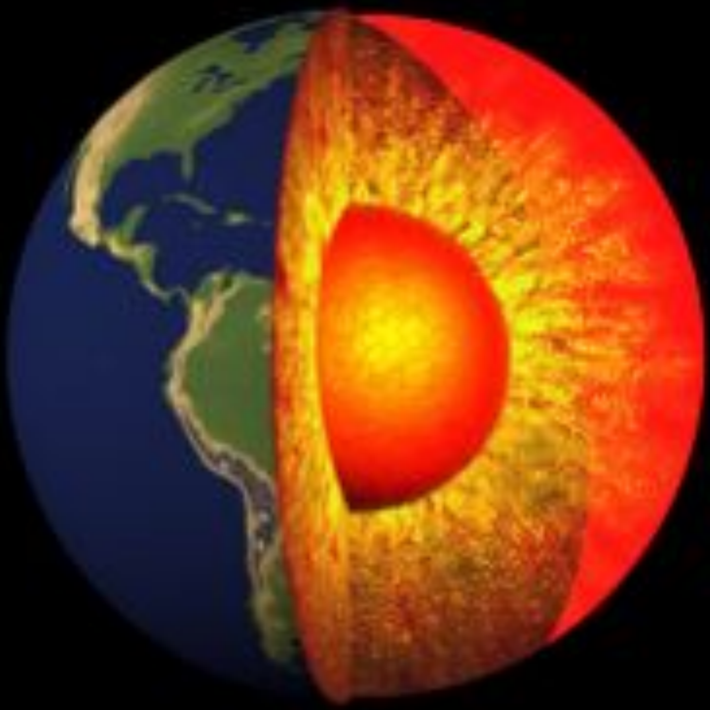
- Iron mixed with nickel, oxygen – metallic
- 3500 km thick
- Outer core: liquid; convects heat & generates a magnetic field
- Inner core: solid; over 4,300°C

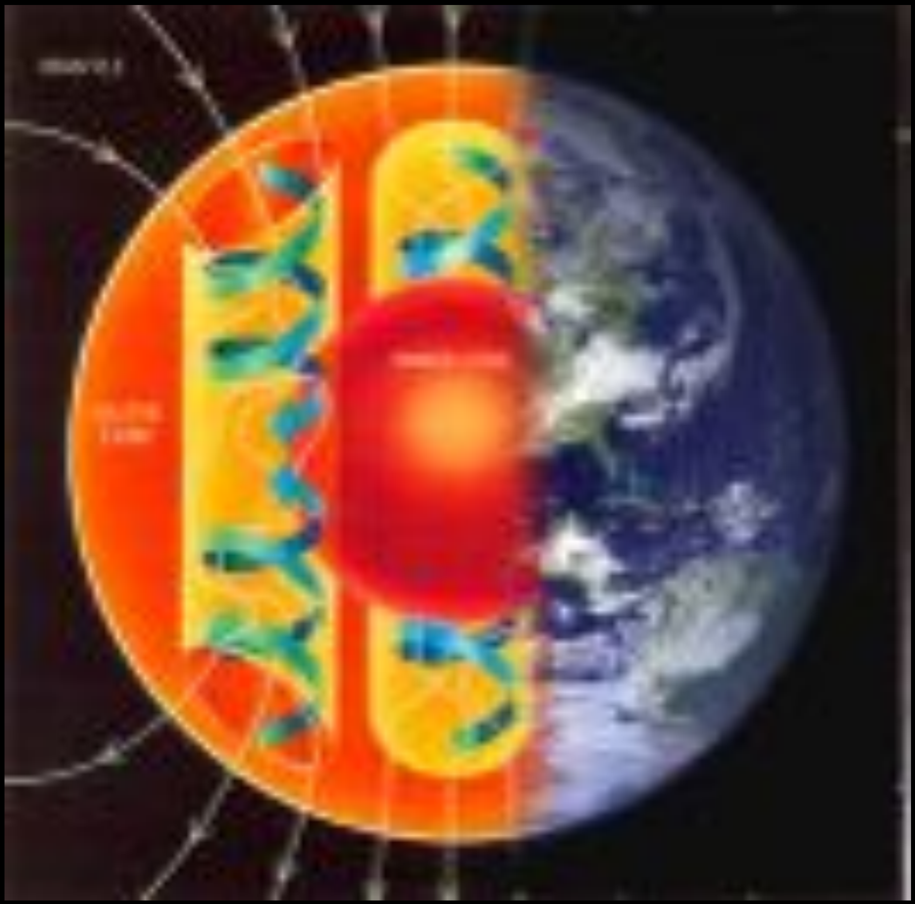
Iron-nickel



Earth's Core & Magnetic Field

• Fluid motion of liquid iron in the outer core generates Earth's magnetic field





Earth's Mantle

- Made of solid rock: Silicate (silicon + oxygen)
- 2900 km thick
- Moves heat around through convection
- Mantle rock also deforms as a fluid

Like Silly Putty, behaves as a:
Solid – over short time
Fluid – over long time

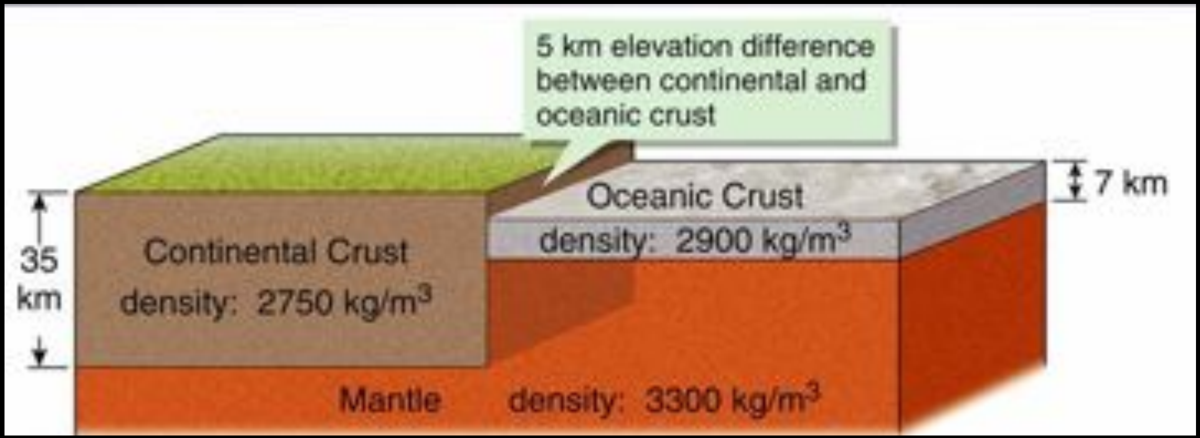
Earth's Crust

Continental Crust (~35 km thick)

- Formed early in Earth's history
- Rocks less dense than mantle rocks
- Is essentially "floating" on the mantle

Oceanic Crust (~7 km thick)

- Is currently being formed
- Is denser than continental crust (more iron + magnesium)



Like floating ice extends deeply below water level

What is a Mineral?

Minerals are natural, inorganic, solid crystalline compounds with a definite (but variable) chemical composition

- natural occurrence
- inorganic
- solid

- has a crystalline structure*
- has a definite chemical composition*

Minerals

Olivine $(Mg,Fe)_2SiO_4$

Copper (Cu)

Ice (H_2O)

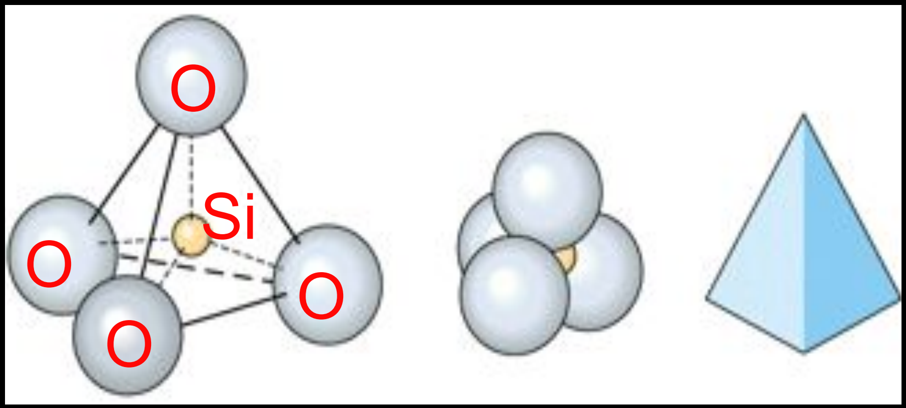
Halite (NaCl)
Salt

Pyrite (FeS_2)
Fool's Gold

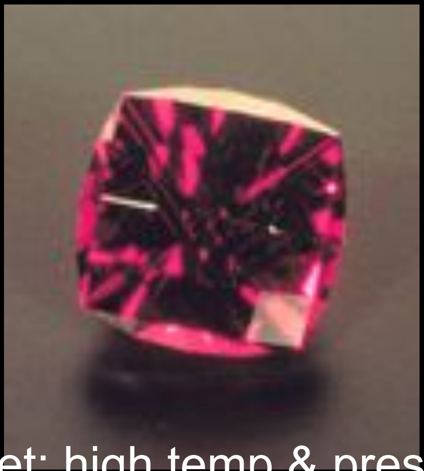
Gypsum
$(CaSO_4)$-2(H_2O)

Silicates (Si + O)

- Si & O are most common elements
- Fundamental unit: silicate tetrahedron (4-sided pyramid)
  - -1 Si + 4 O atoms



Under special conditions, rare silicates may crystallize

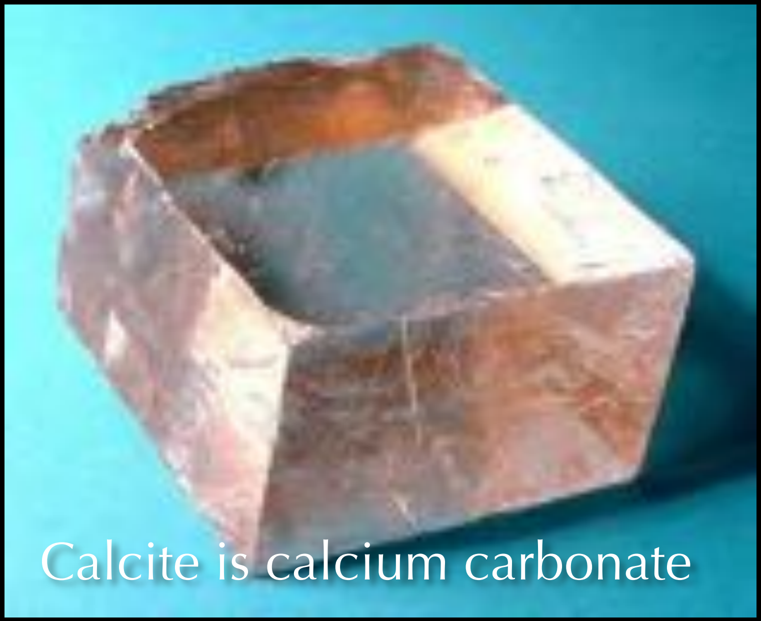


Garnet: high temp & pressure

Carbonates

- Contain carbonate anion $(CO_3)^{-2}$
- Form in waters saturated by calcium (oceans) and as a result of biological processes

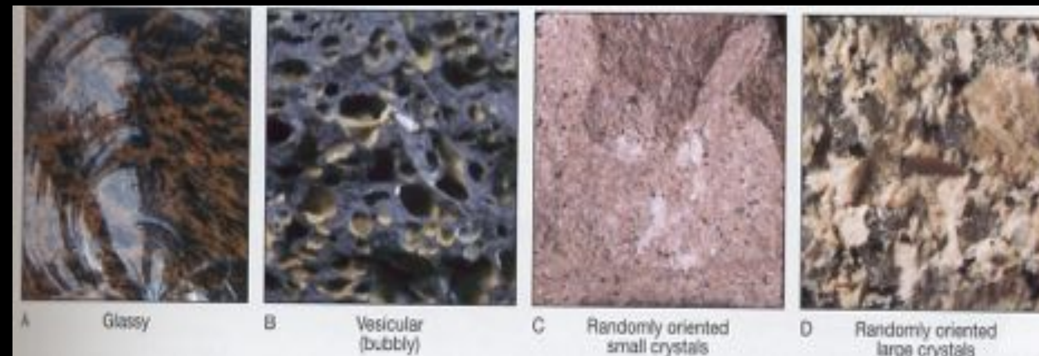
- Examples: calcite $CaCO_3$ --> limestone



limestone

Fundamental Rock Types

- <u>Igneous Rocks:</u>
  form when magma solidifies

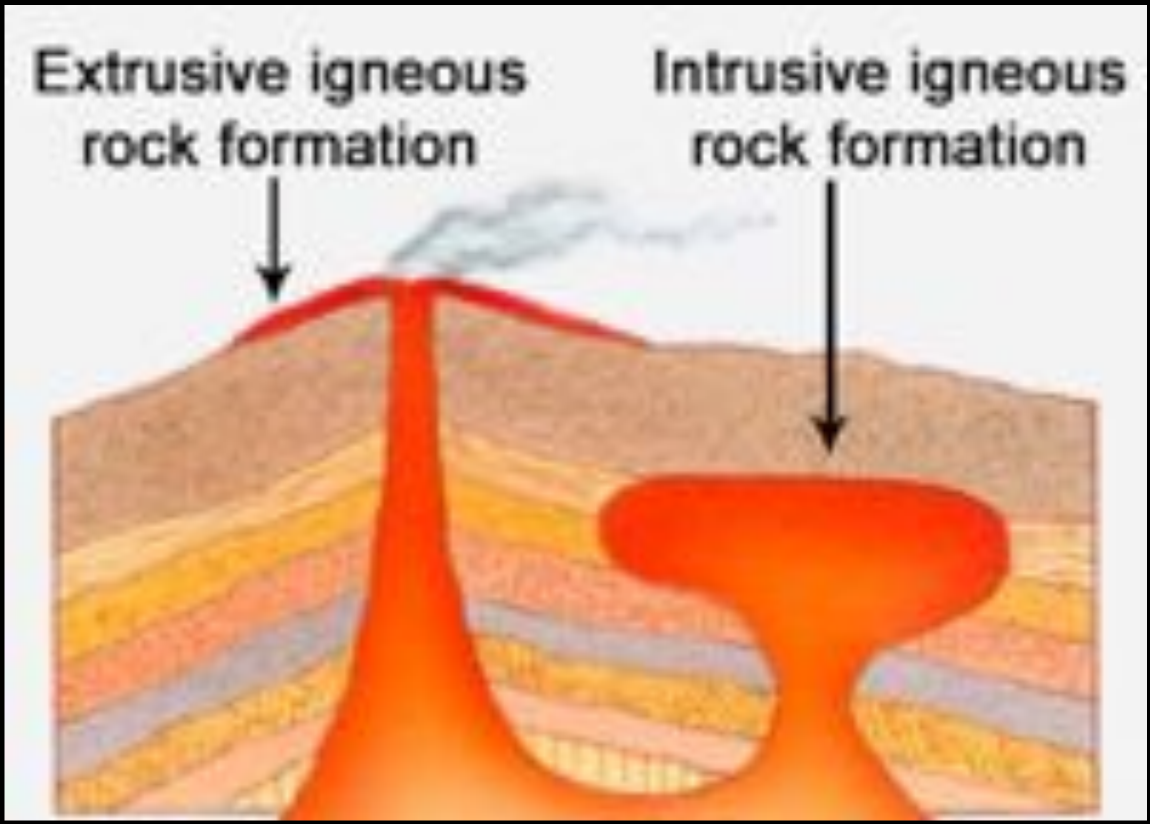


- <u>Sedimentary Rocks:</u>
  form when sediment becomes cemented into solid rock

- <u>Metamorphic rocks:</u>
  form when heat, pressure, or hot water alter any preexisting rock

Types of Igneous Rocks

- Extrusive (volcanic)
  - forms when magma erupts & solidifies on the surface
- Intrusive (plutonic)
  - forms when magma solidifies within the crust



Extrusive Igneous Rocks

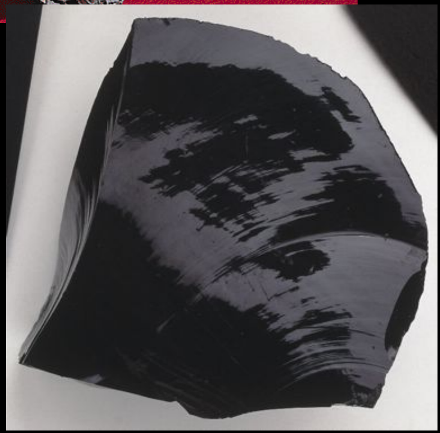
- Lava: fluid magma that flows from a crack or volcano onto Earth's surface

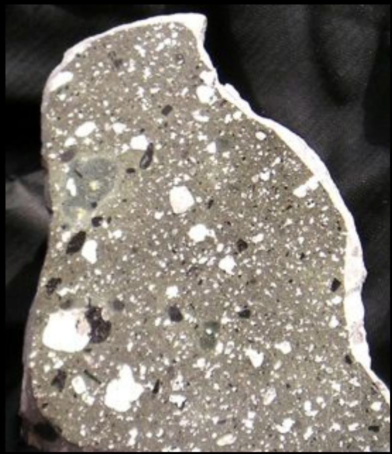
- Magma cools quickly = less time for crystals to form

- Ex.: Basalt - common volcanic rock, ocean crust, few crystals


Lava


Basalt


Obsidian


Porphyric rock

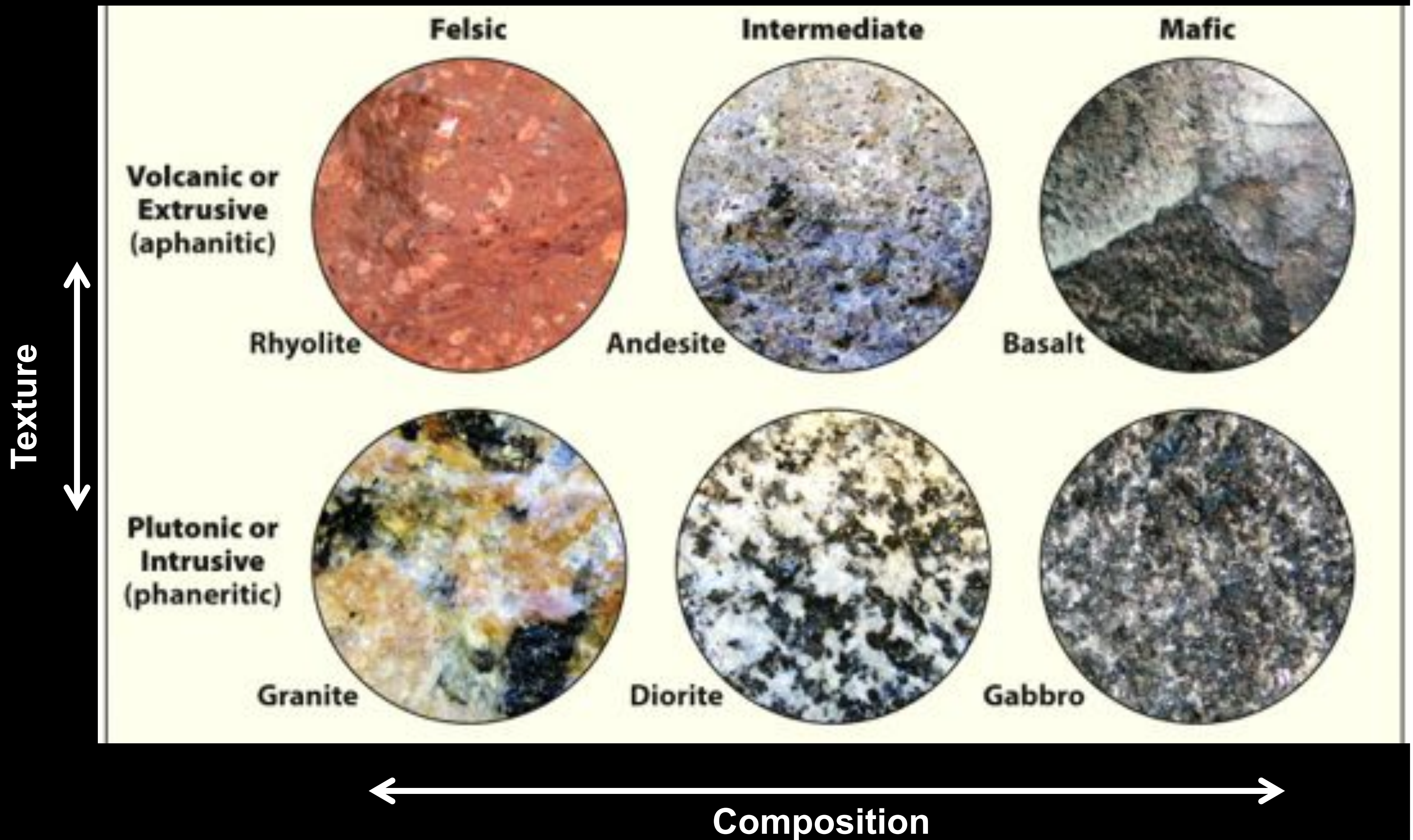

Rhyolite

Igneous rocks are classified based on their <u>composition</u> and <u>texture</u>

Composition: assemblage of minerals (Si vs. Mg)

Texture: size and arrangement of crystals (cooling history)

The Major 7 Types of Igneous Rocks



Composition Types

- Felsic: Feldspar & Silica
  Granite (large grains), Rhyolite (small)
- Mafic: Magnesium & Iron (Fe)
  Gabbro (large), Basalt (small)
- Ultramafic: High Mg & Fe
  Peridotite (mantle material, rare)
- Intermediate:
  Andesite

Felsic Mafic

Ultramafic

Andesite

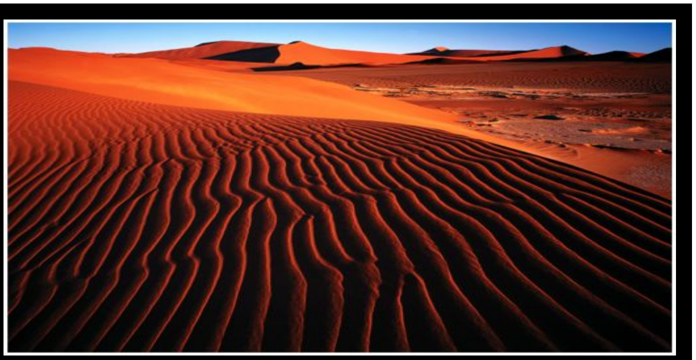
Weathering

- Def.: processes that decompose rocks & convert them to loose gravel, sand, clay, & soil
- Three primary types:
  - Physical
  - Biological
  - Chemical

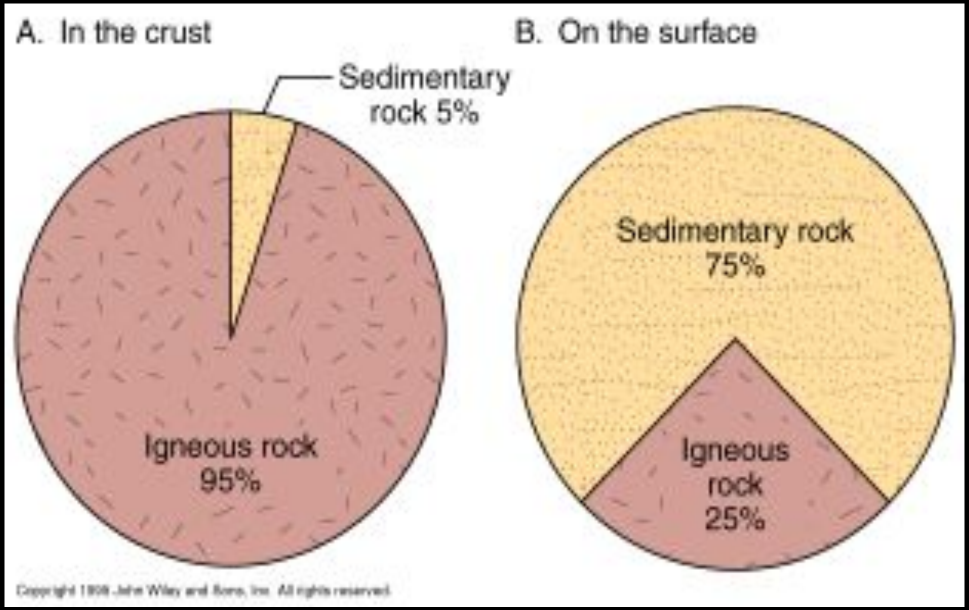
Types of Physical Weathering

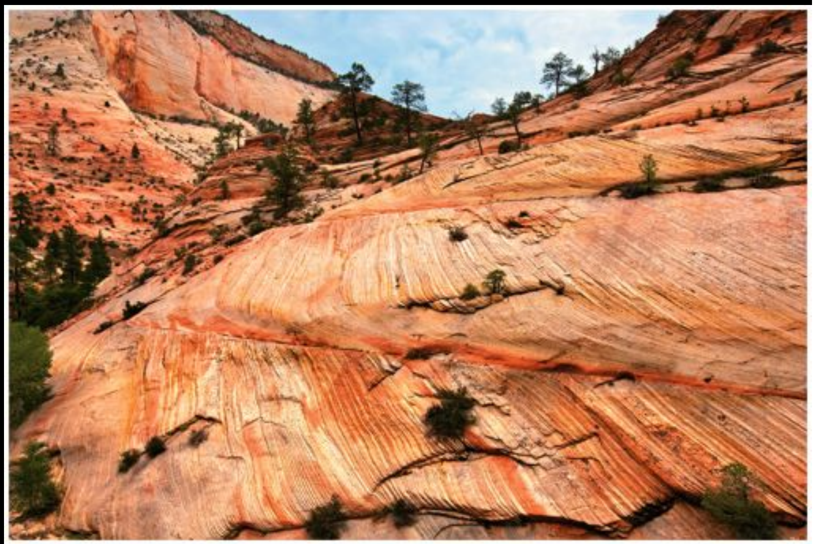
- Pressure-release fracturing
- Abrasion
- Freeze-Thaw (frost wedging)
- Hydraulic Action
- Growth of Salts

Sedimentary Rocks



- Generally, made from older rocks
- Make up only ~5% of Earth's crust, but…..
- Make up 75% of all rocks exposed at the surface





Why Study Sedimentary Rocks?

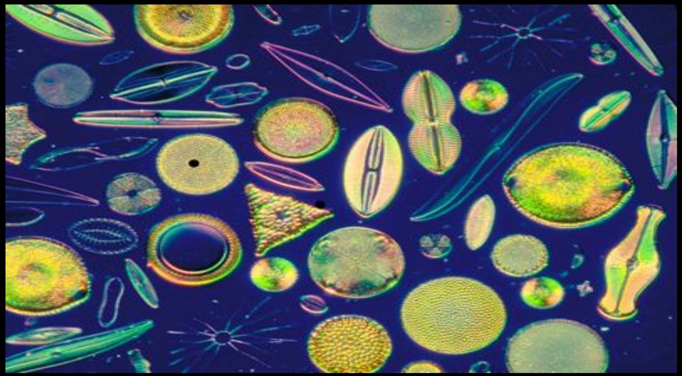
- Reflect physical and chemical characteristics of source environments
- Contain direct and indirect evidence of life
- Can be interpreted to recreate Earth history
- Source of “fossil fuels”

Sedimentary Rock Types

- Clastic – broken down rocks (clasts)
  Ex.: sandstone

- Chemical – directly precipitates out of water
  Ex.: rock salt

- Biogenic – remains of living organisms
  Ex.: limestone, chalk, coal



Types: Chemical Sedimentary Rocks

rock salt

rock gypsum

limestone

travertine

micrite

dolostone

chert

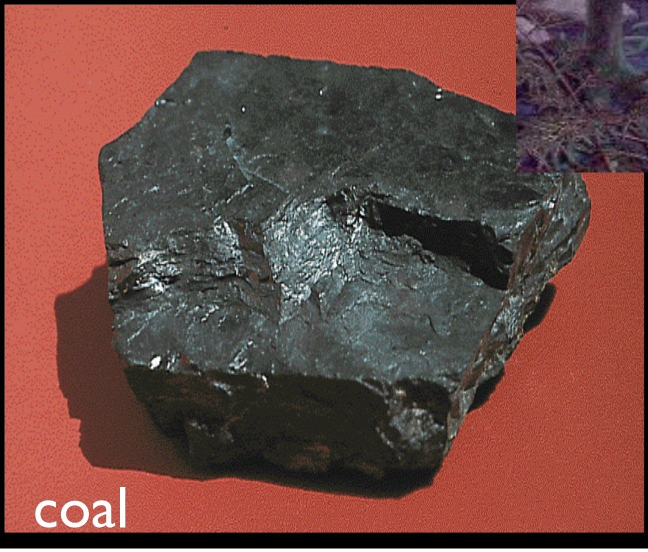
TABLE 8.4 Chemical Sedimentary Rocks

Rock	Texture	Composition
Chert	Crystalline	Microcrystalline silica
Dolostone	Crystalline	Dolomite
Limestone	Can be crystalline or microcrystalline	Calcite
Micrite	Microcrystalline	Carbonate mud
Rock gypsum	Crystalline	Gypsum
Rock salt	Crystalline	Halite
Travertine	Microcrystalline	Calcite from saturated fluids

Types: Biogenic Sedimentary Rocks

- Lithification of “organic” (plants, etc.) material
- Ex.: Coal is formed from preserved plant material in swamps

Coal swamp forest

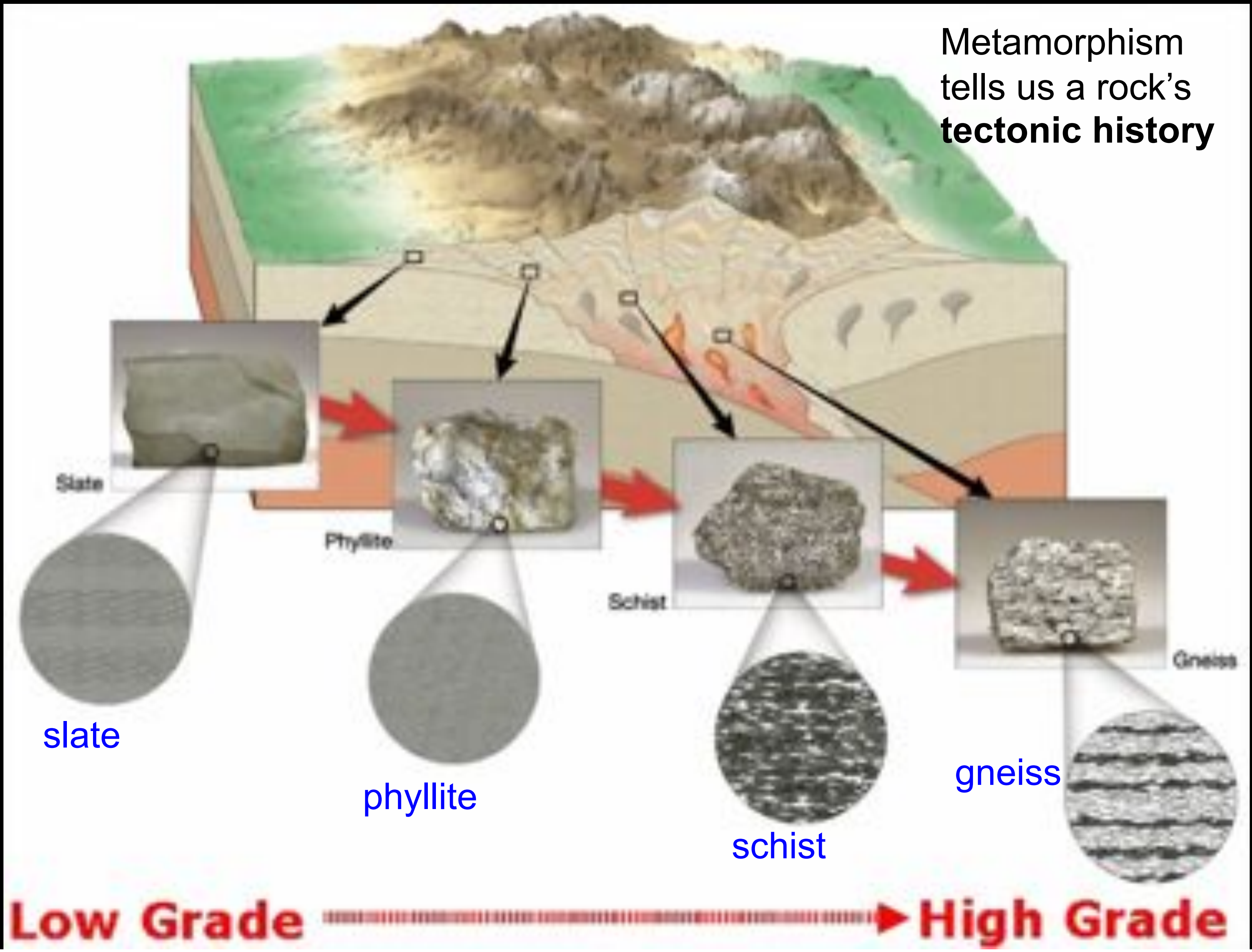


Metamorphic Rocks

- Metamorphism: process of rising temperature & pressure, or changing chemical conditions, that transforms rocks & minerals
- Ways: 1. Heat 2. Pressure 3. Fluid activity



Metamorphic Grade



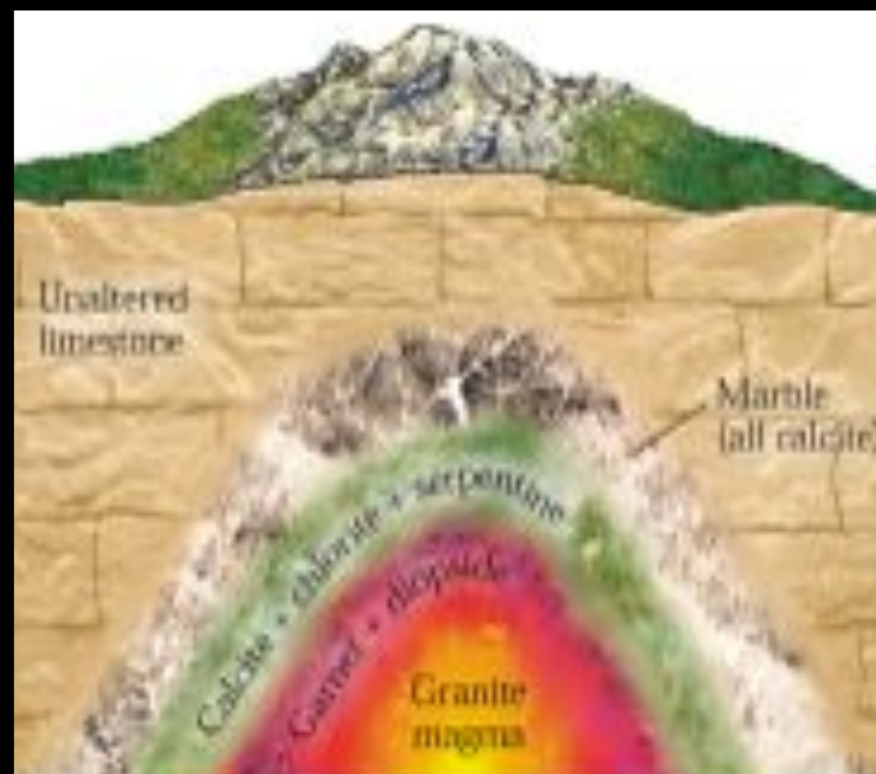
Types of Metamorphism

- Contact
- Regional
- Hydrothermal

separate processes, but can happen @ same time

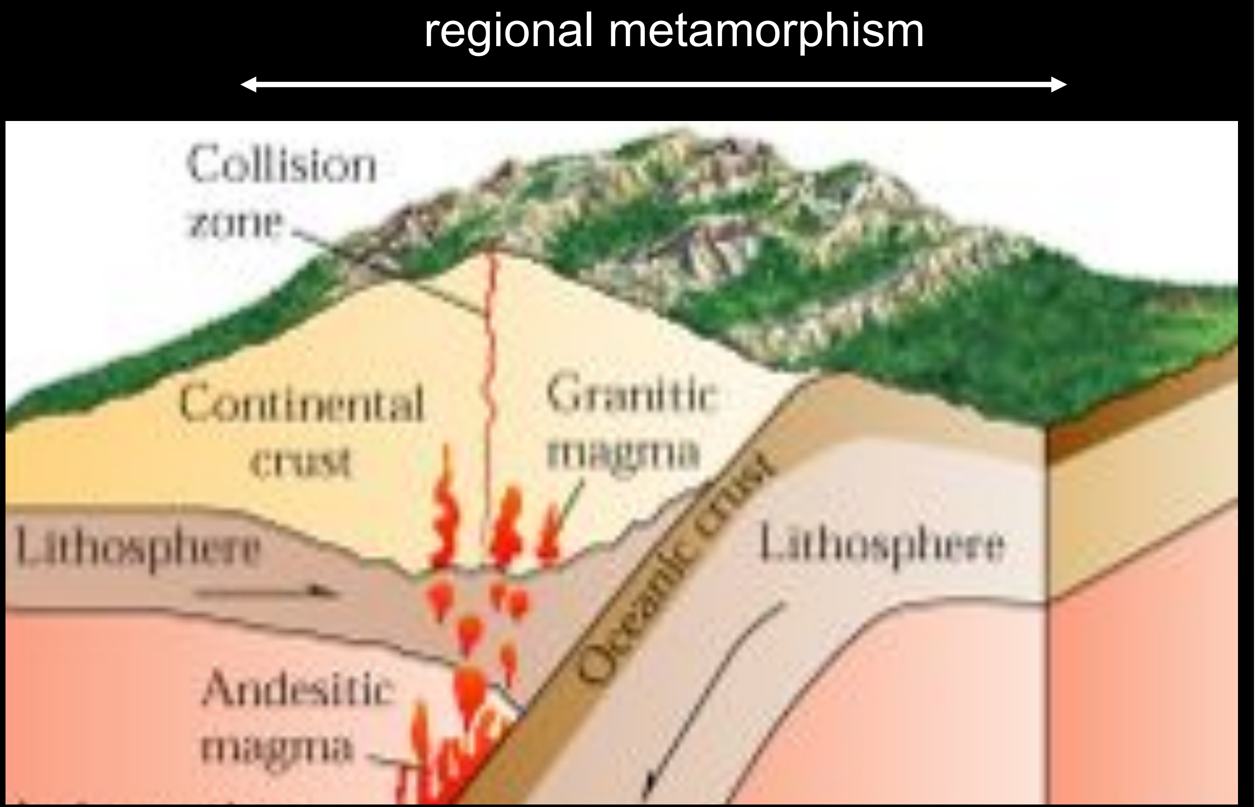
Contact Metamorphism

- when magma comes in contact with basement rock at shallow depth and heats it up
- magma also brings reactive fluids



Regional Metamorphism

- When major crustal movements build mountains and deform rocks
- Rocks deformed & heated at same time



Hydrothermal Metamorphism

- Heat and pressure release chemically active fluids from rocks.
- These fluids transport heat, ions dissolve in hot water
- Reactions promote recrystallization

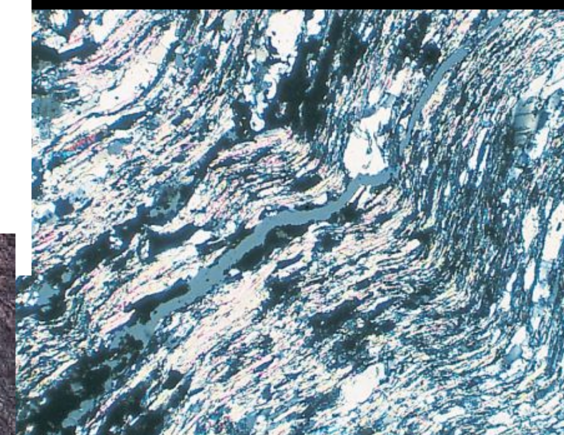
Water

Basalt

Serpentinite

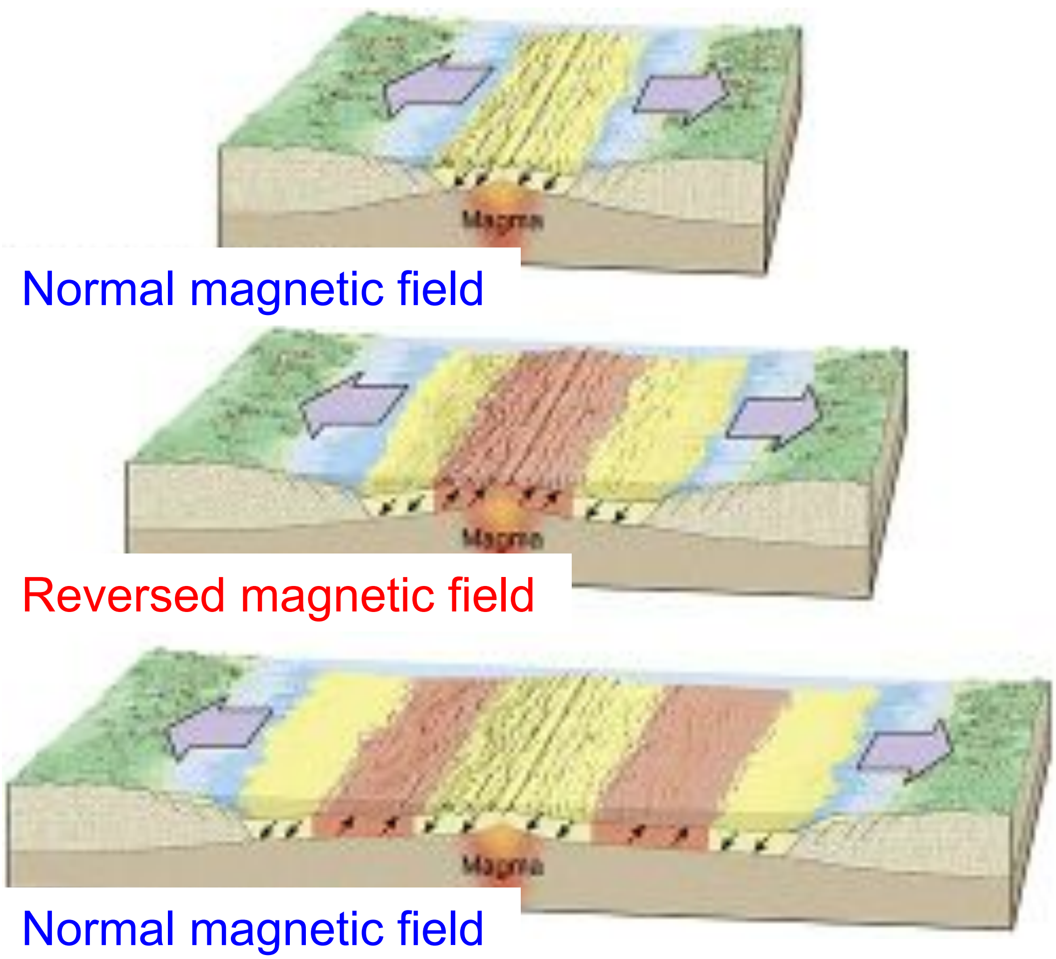
Common Metamorphic Rocks

- Slates
- Phyllite
- Schists
- Gneisses



Seafloor Magnetic Reversals

- Oceanic crust preserves a record of Earth's magnetic polarity at the time the crust formed

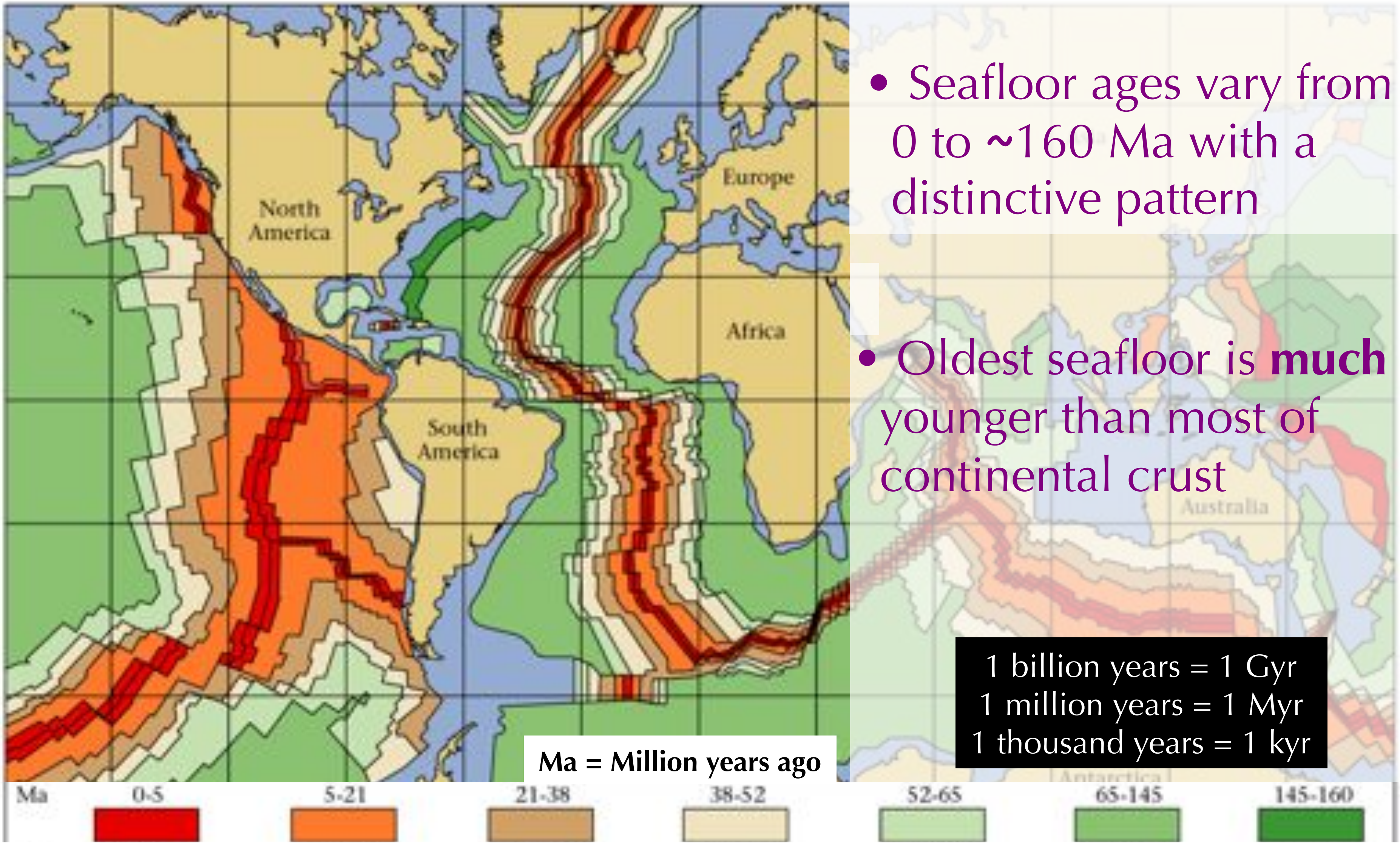


New seafloor is being created as the seafloor spreads.

The continents move apart as new seafloor expands the ocean basin

The magnetic field is "frozen" in the newly-created seafloor.

Ages of the Ocean Floor



- Seafloor ages vary from 0 to ~160 Ma with a distinctive pattern
- Oldest seafloor is **much** younger than most of continental crust

1 billion years = 1 Gyr
1 million years = 1 Myr
1 thousand years = 1 kyr

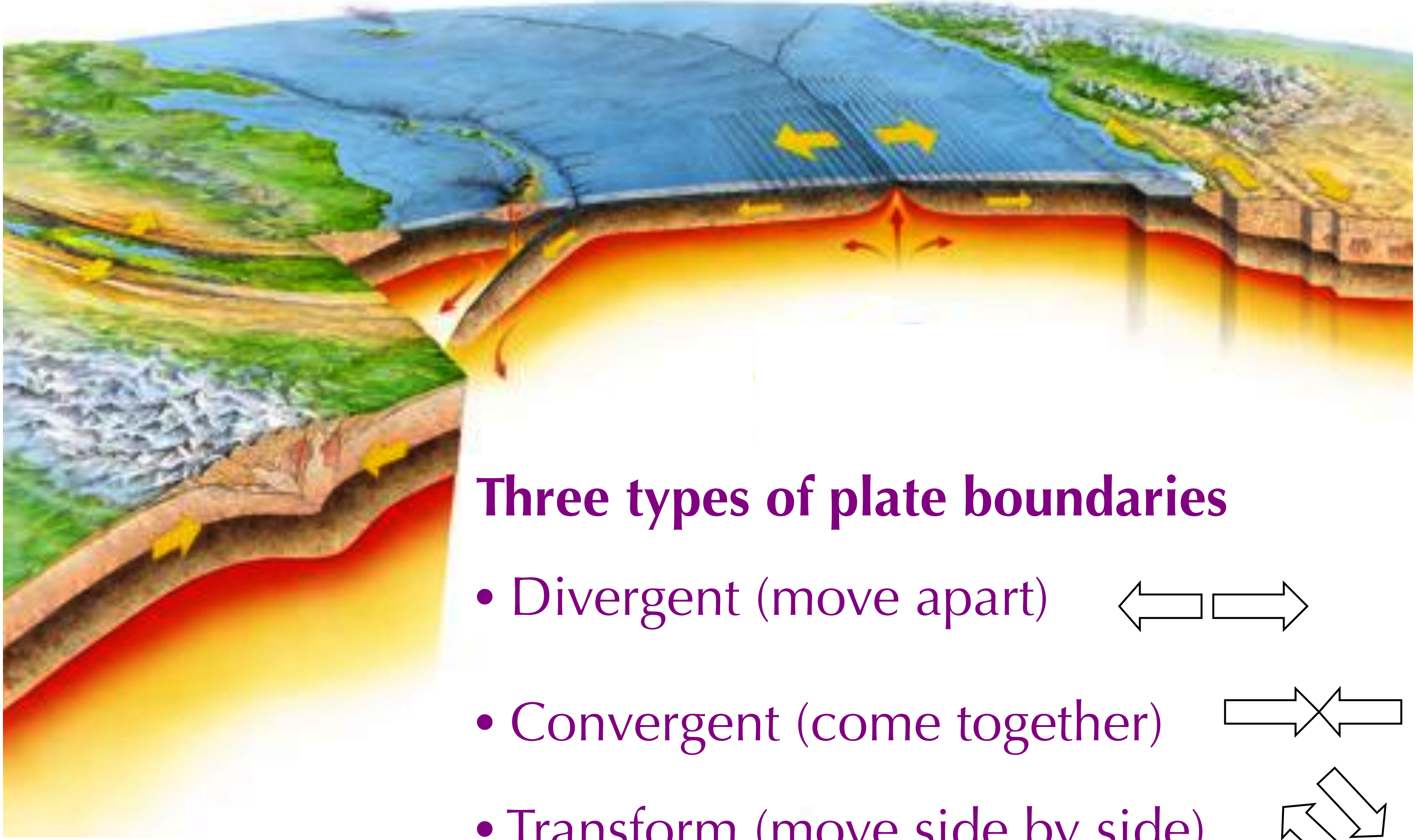
Ages of Continental Rocks

Time span (billions of years ago)

0.25 to 0	2.5 to 1.7	2.5 to 0.7
0.7 to 0.25	3.8 to 2.5	3.8 to 1.7
1.7 to 0.7		

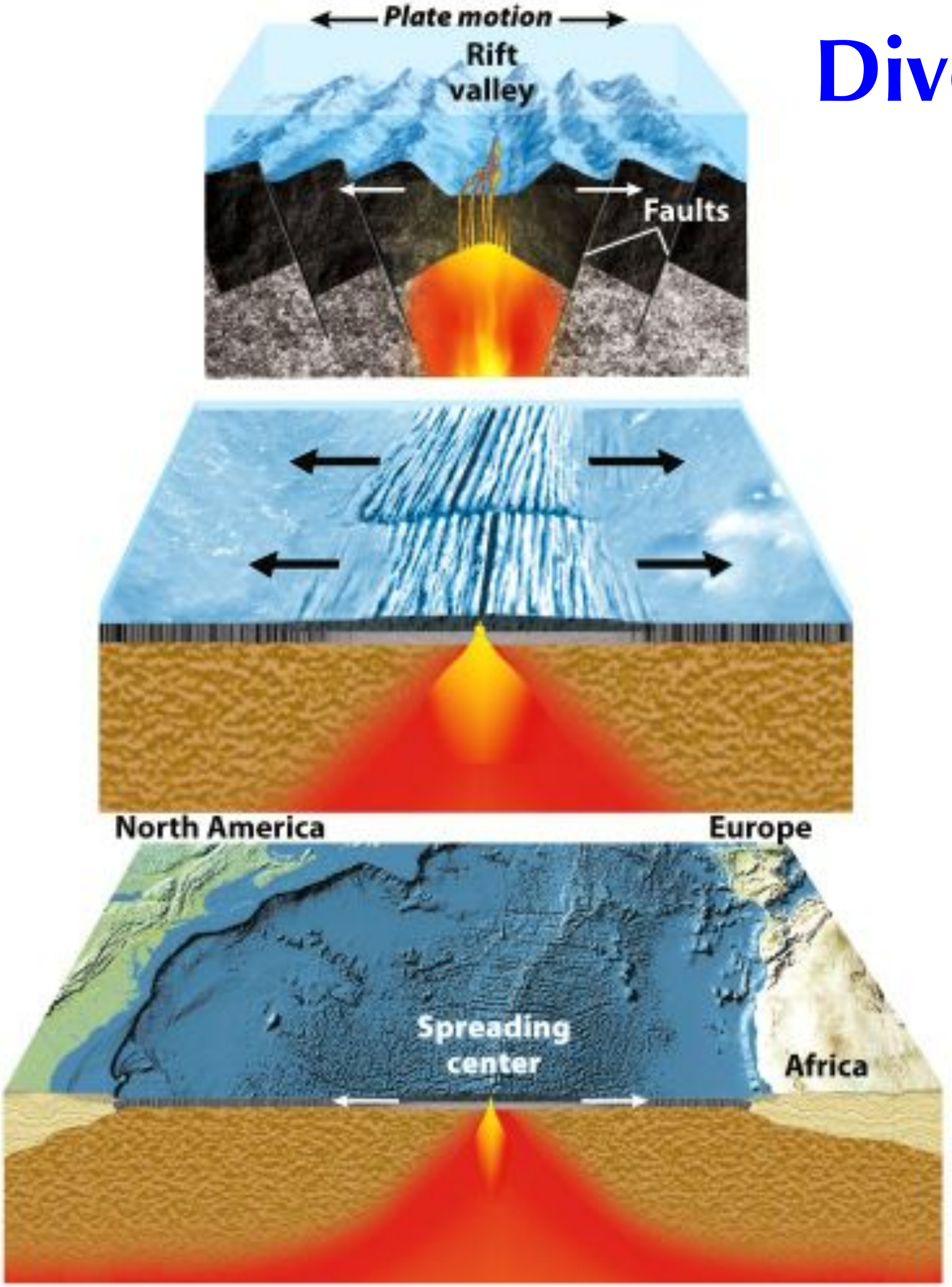
- Age of the Earth: 4.5 Gyr
- Oldest continent rocks: 3.8 Gyr
- Youngest continent rocks: 250 Myr

Plate Boundaries



Three types of plate boundaries

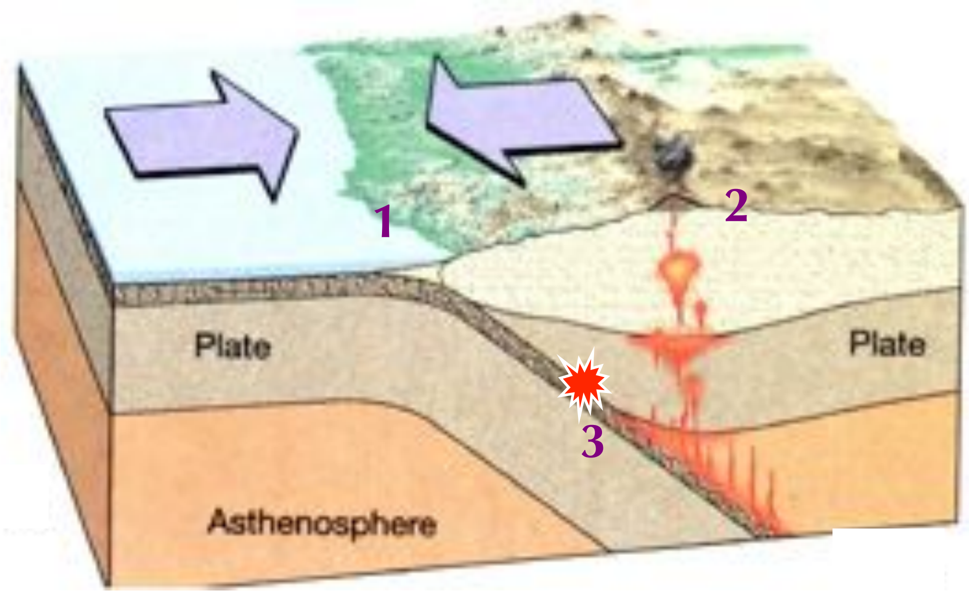
- Divergent (move apart)
- Convergent (come together)
- Transform (move side by side)



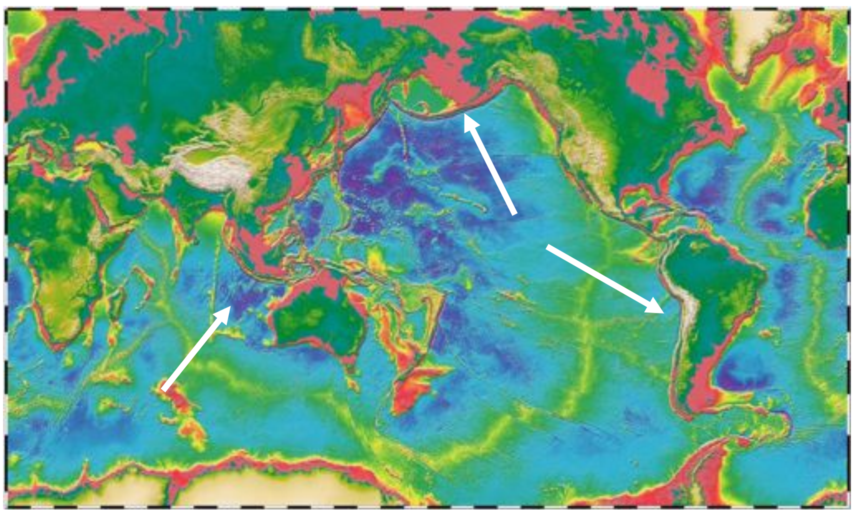
Divergent Boundary

As two plates continue to move apart, the rock in the seafloor grows older as its distance from the rift zone increases

Convergent Plate Boundaries

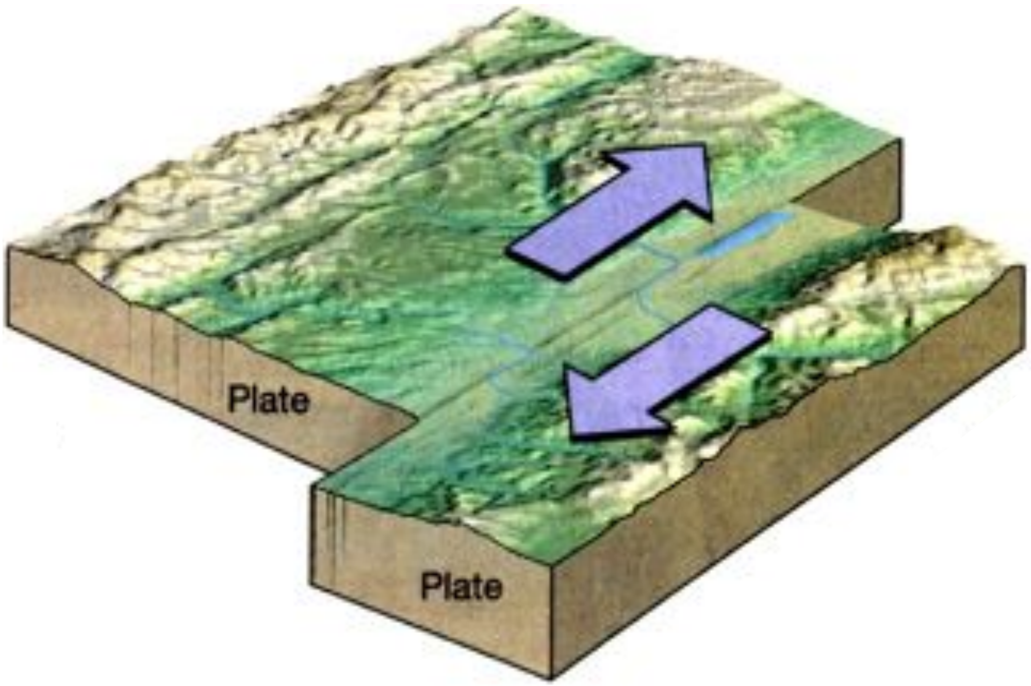


- Plates collide
- Subduction zones
- We observe:
  1) Trench
  2) Volcanoes
  3) Earthquakes

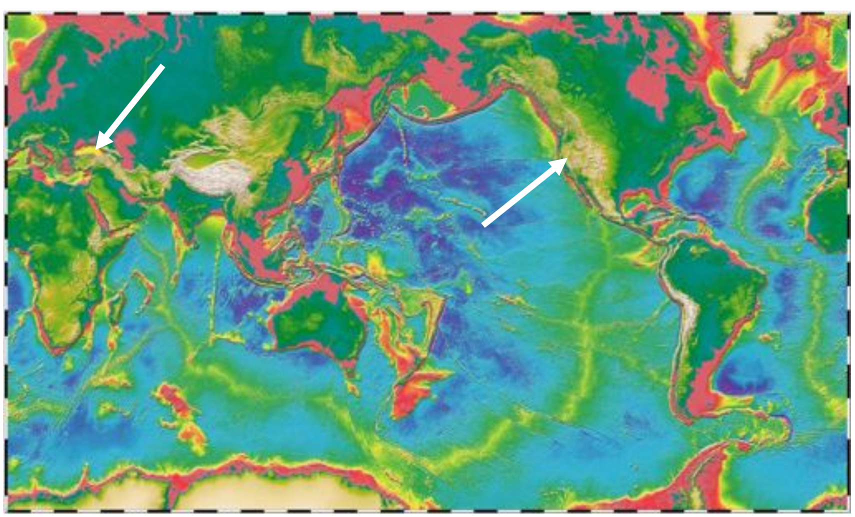


- Examples
  - Peru-Chilean Coast
  - Alaskan Coast
  - Sumatran Coast

Transform Plate Boundary



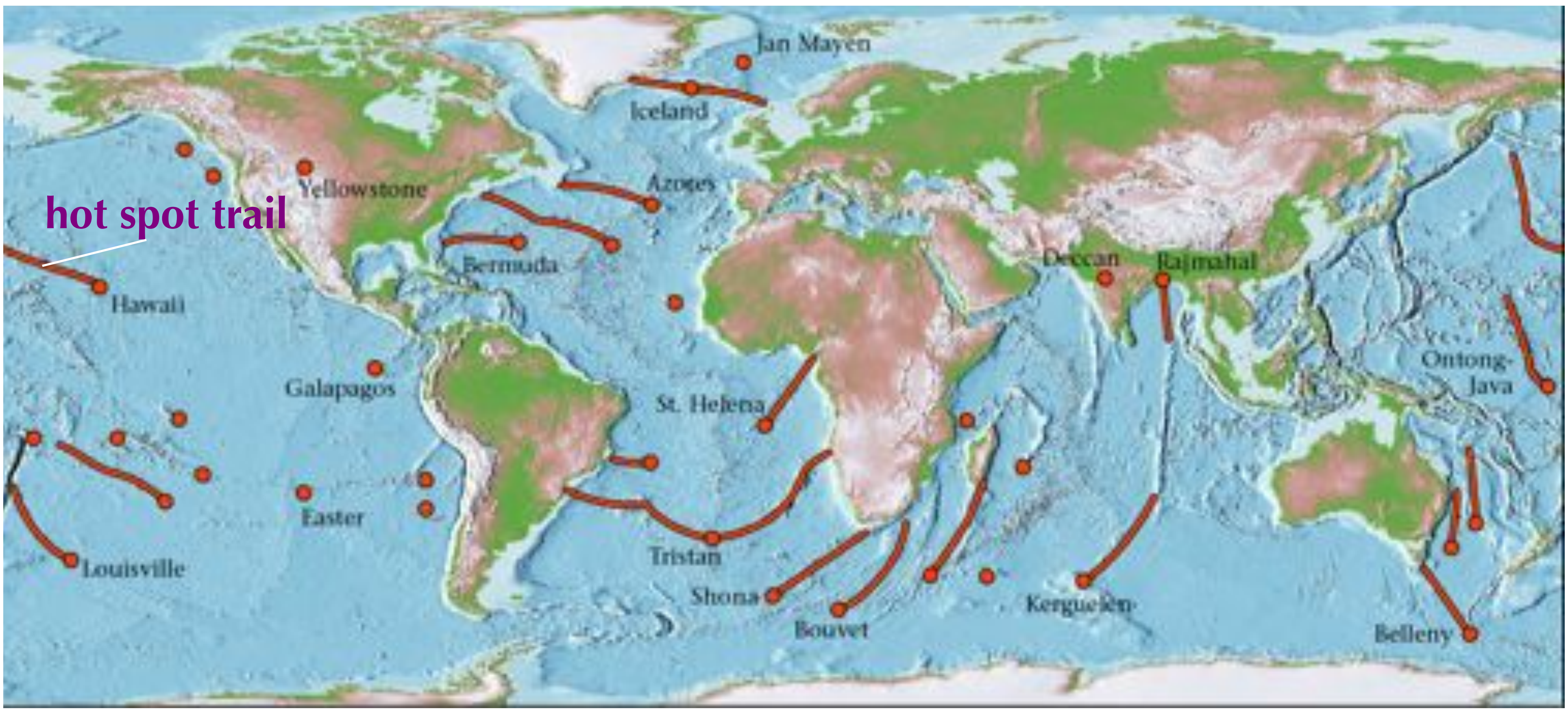
- Plates slide by
- Transform faults
- We observe:
  1) Offset surface features
  2) Earthquakes



- Examples
  - San Andreas Fault
  - North Anatolian Fault (Turkey)

Hot Spots

- sometimes marked by chain of islands
- less common than plate-boundary volcanoes
- different composition (deep source)



Three Common Types of Magma:

Aa - rough, fragmented lava blocks called "clinker"

BASALTIC

Basaltic lava flows easily because of its low viscosity and low gas content.

The low viscosity is due to low silica content.

Pahoehoe - smooth, shiny, and ropy surface

Three Common Types of Magma:

ANDESITIC

- Erupts explosively because it has high gas content
- It is viscous and therefore traps gas.
- High viscosity is related to high silica content

Three Common Types of Magma:

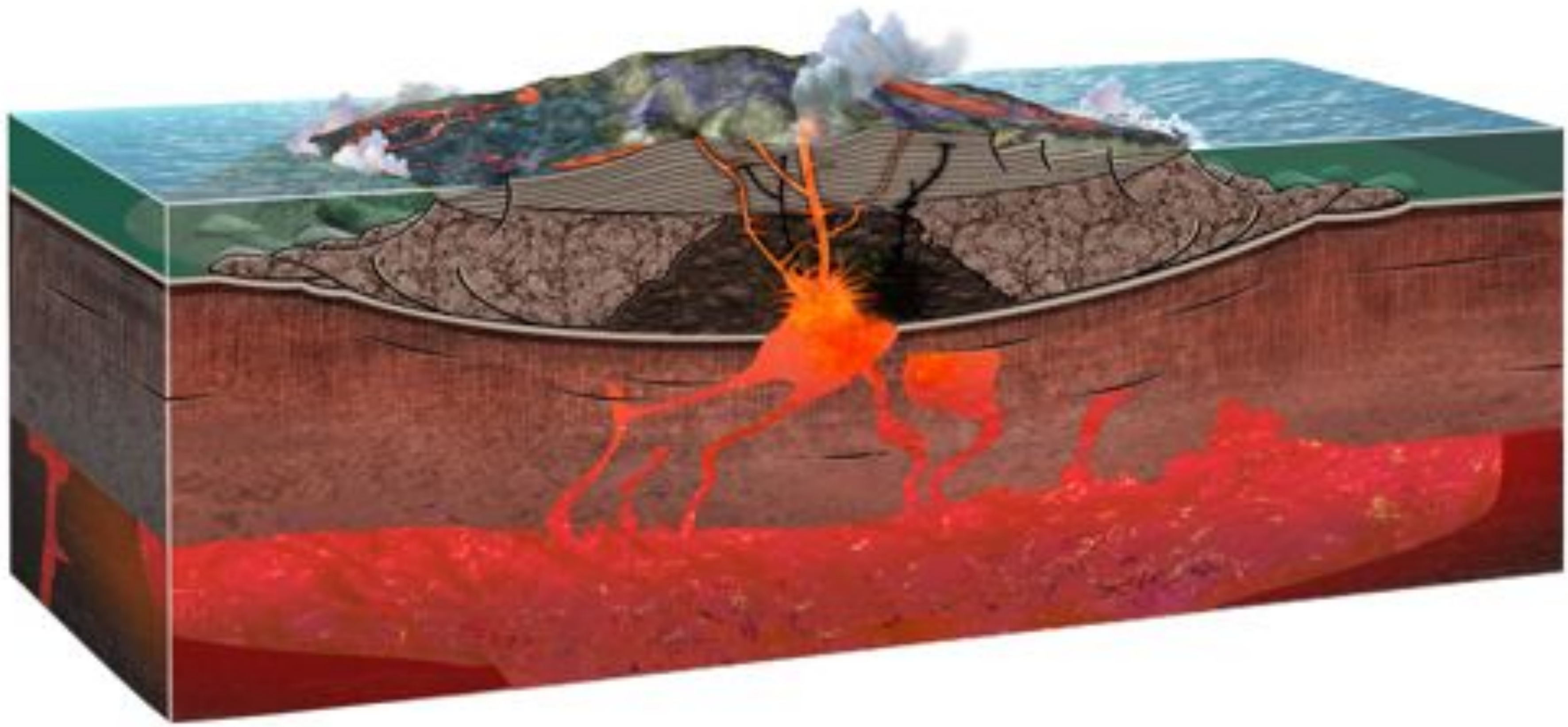
Rhyolitic lava flow

RHYOLITIC

- **Erupts catastrophically because it has high gas content.**
- **It is viscous and therefore traps gas, builds pressure and explosively erupts.**
- **High viscosity → high silica content**

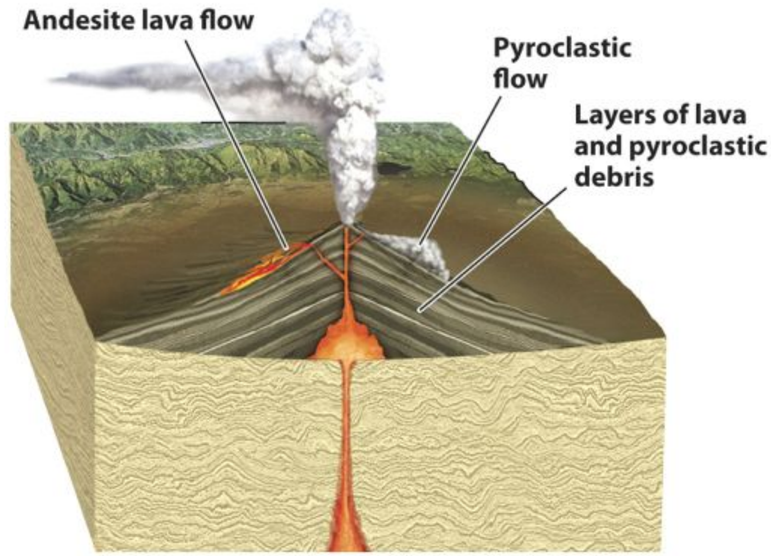
Shield Volcano

- Low silica, low gas magma originates in the mantle.
- Fluid, basaltic lava results in “Aa” and “Pahoehoe”.
- Low viscosity creates broad, gentle slopes.
- **Phreatomagmatic eruptions** occur when lava contacts water (rapid expansion of steam) .

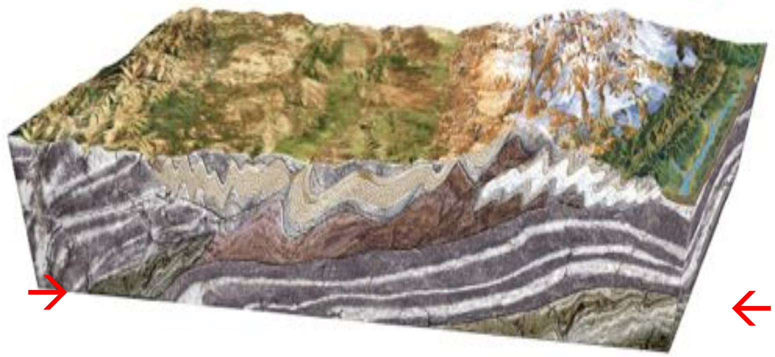


3 Types of Mountains

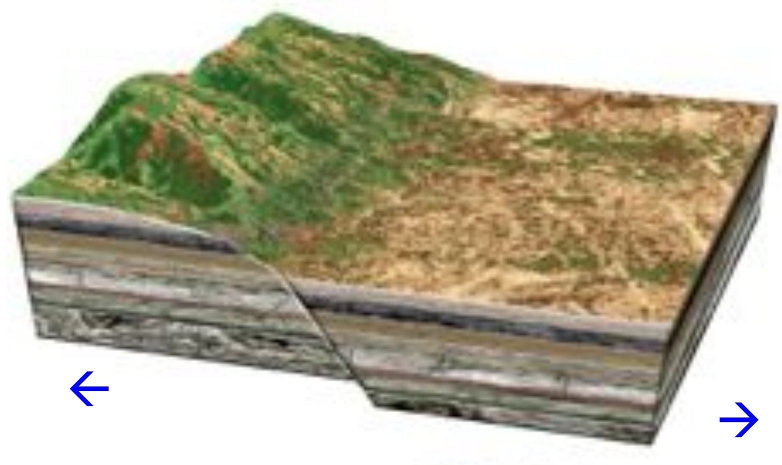
Volcanic Mountains:
Built by accumulation of volcanic materials

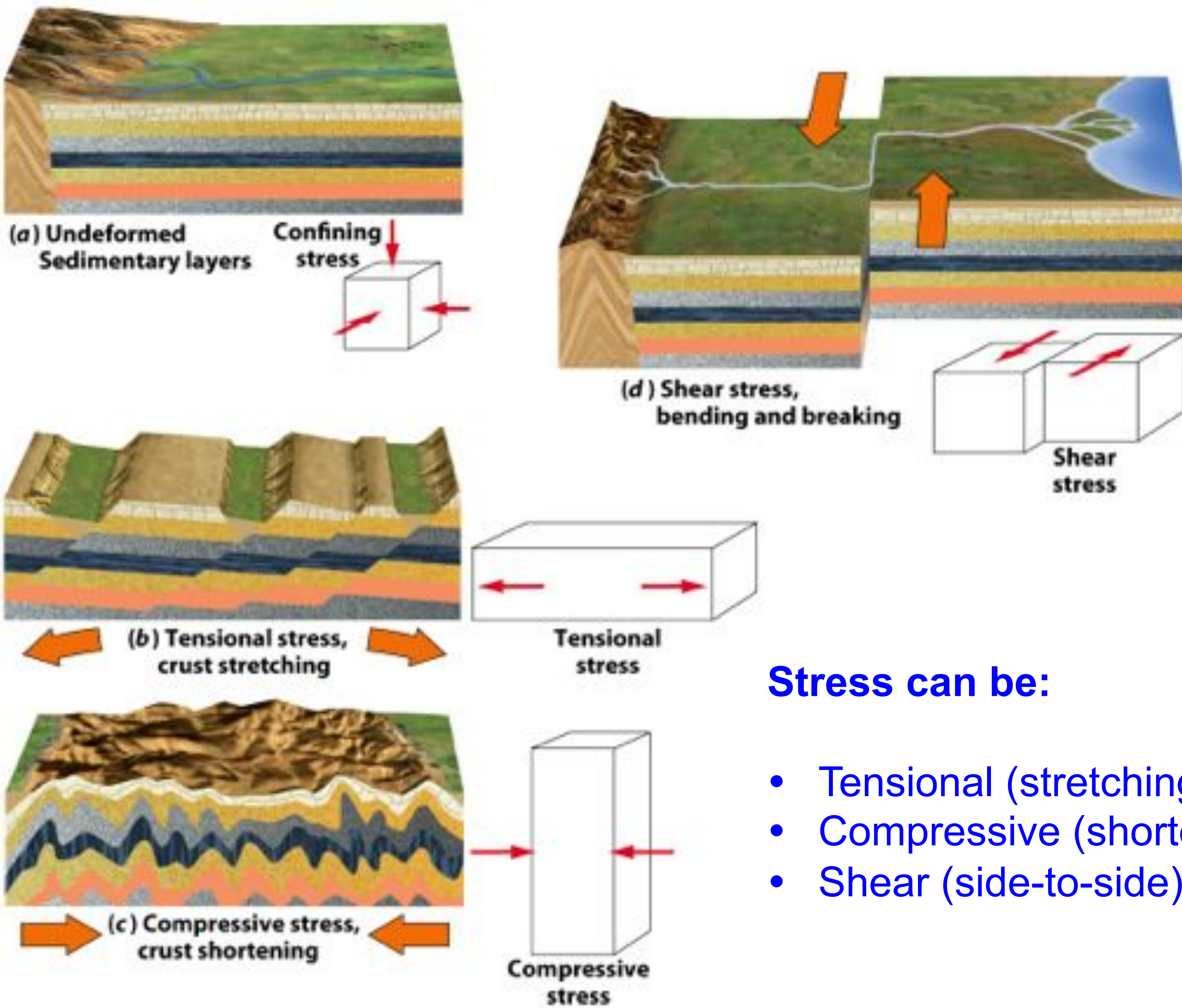


Fold and Thrust Belts:
Built by **compression** stresses



Fault Block Mountains:
Built by **extensional** stresses



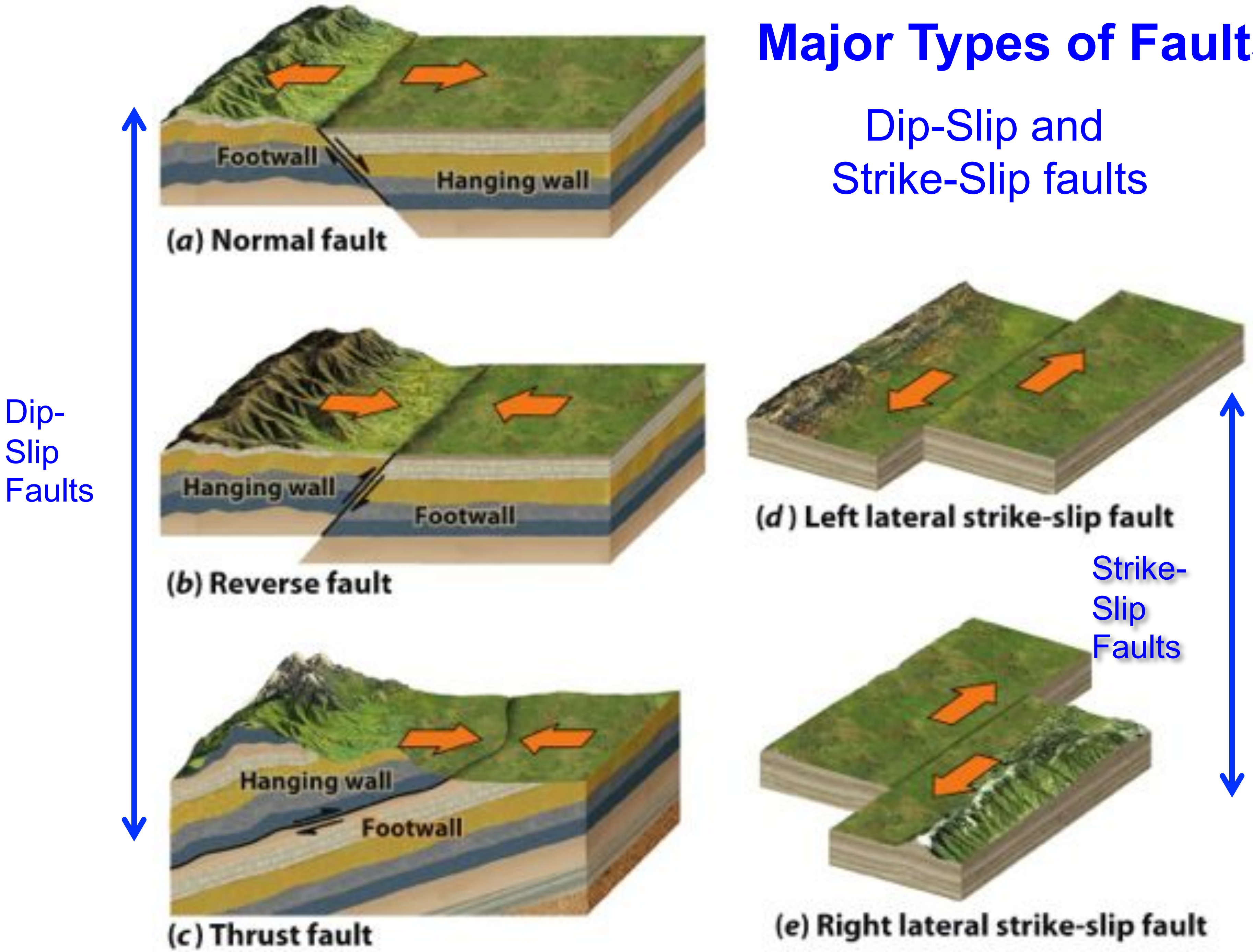


Stress can be:

- Tensional (stretching)
- Compressive (shortening)
- Shear (side-to-side)

Major Types of Faults

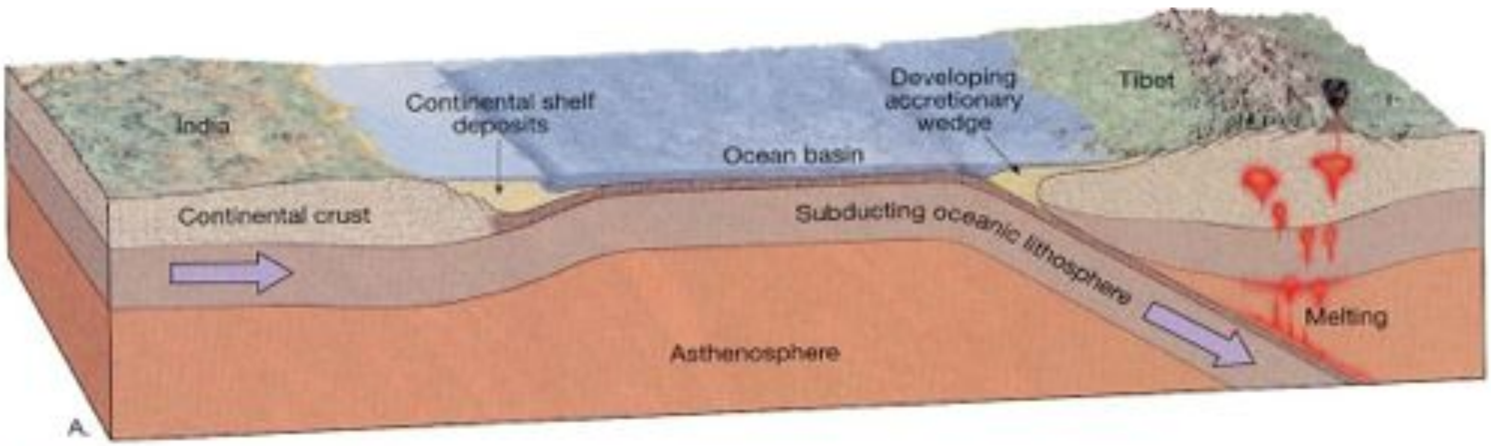
Dip-Slip and Strike-Slip faults

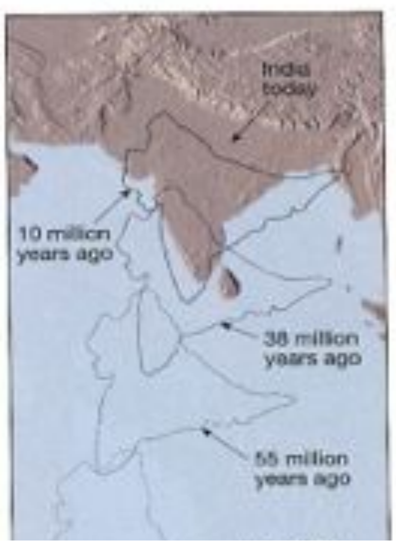


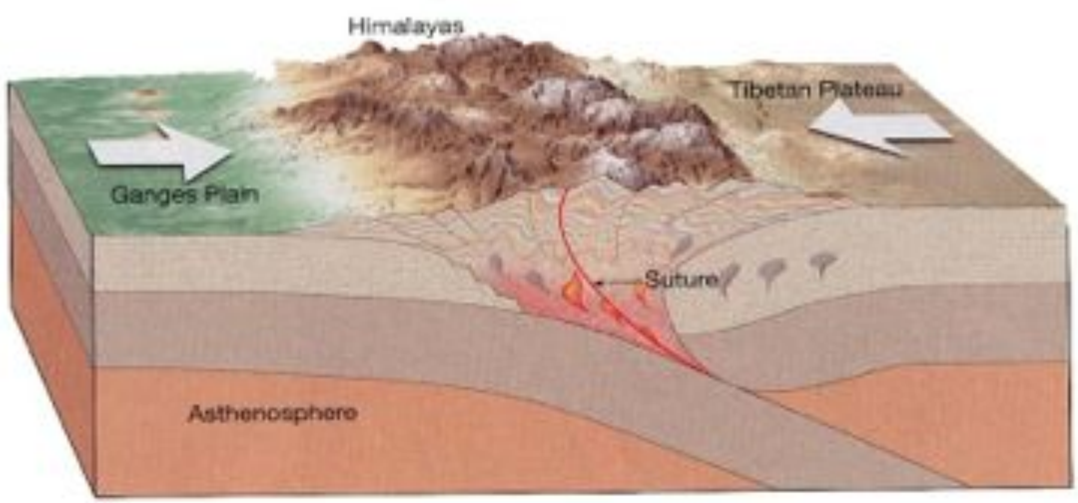
Fold and Thrust Mountains

The Himalayas

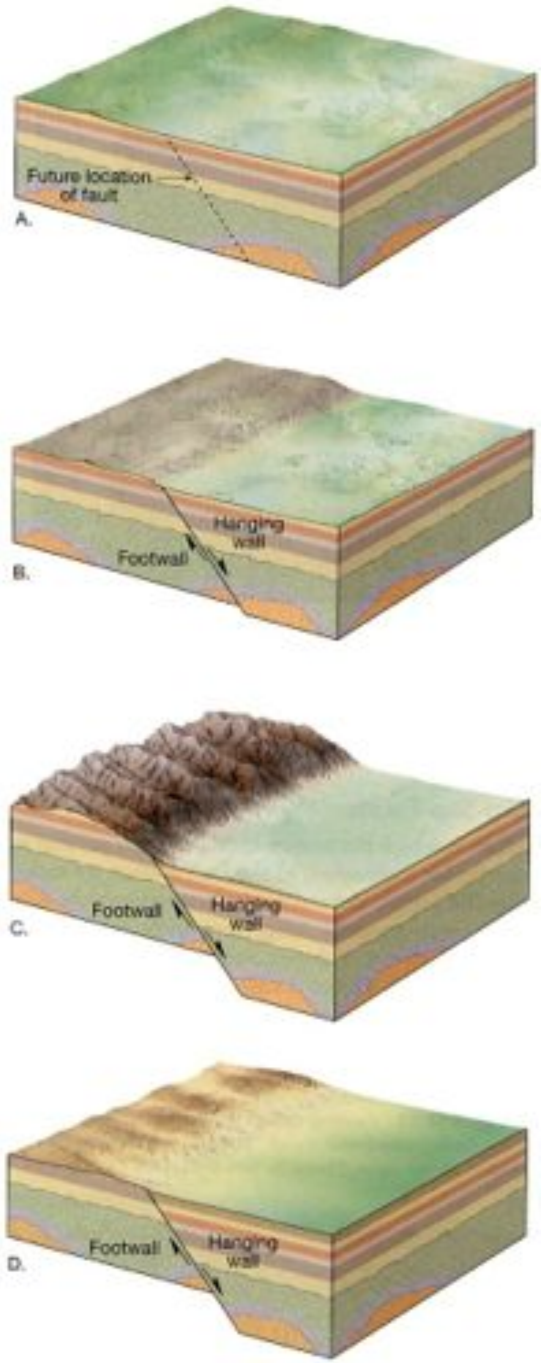
- Collision of India with Eurasia caused compressive stresses.
- These stresses raised the Himalayas and Tibet.

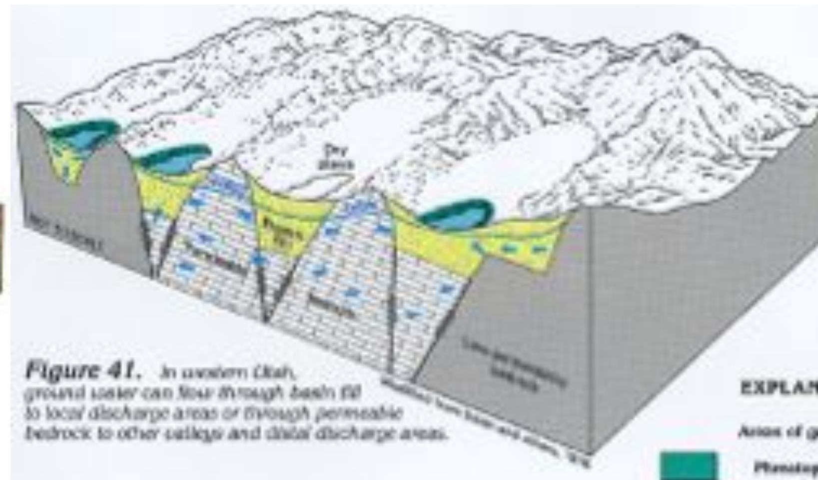


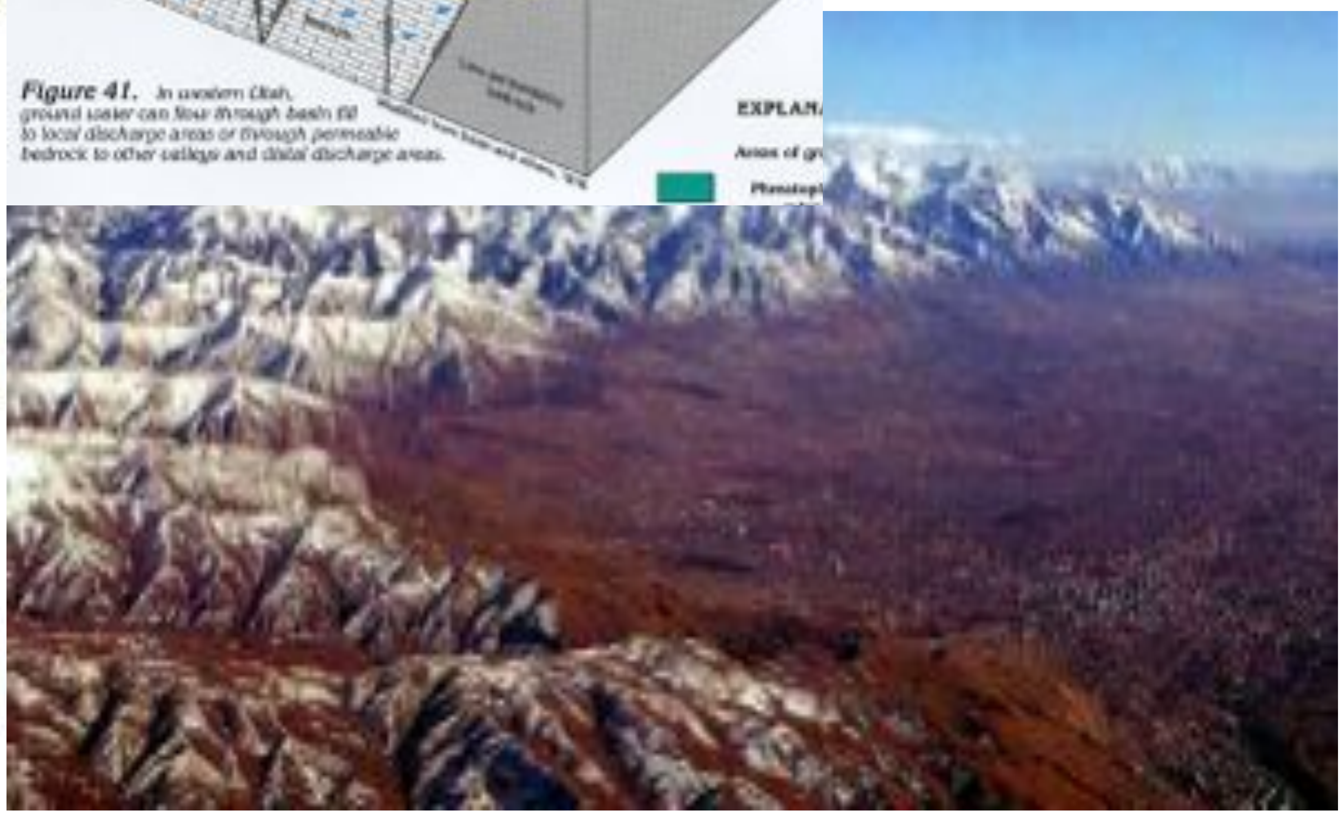




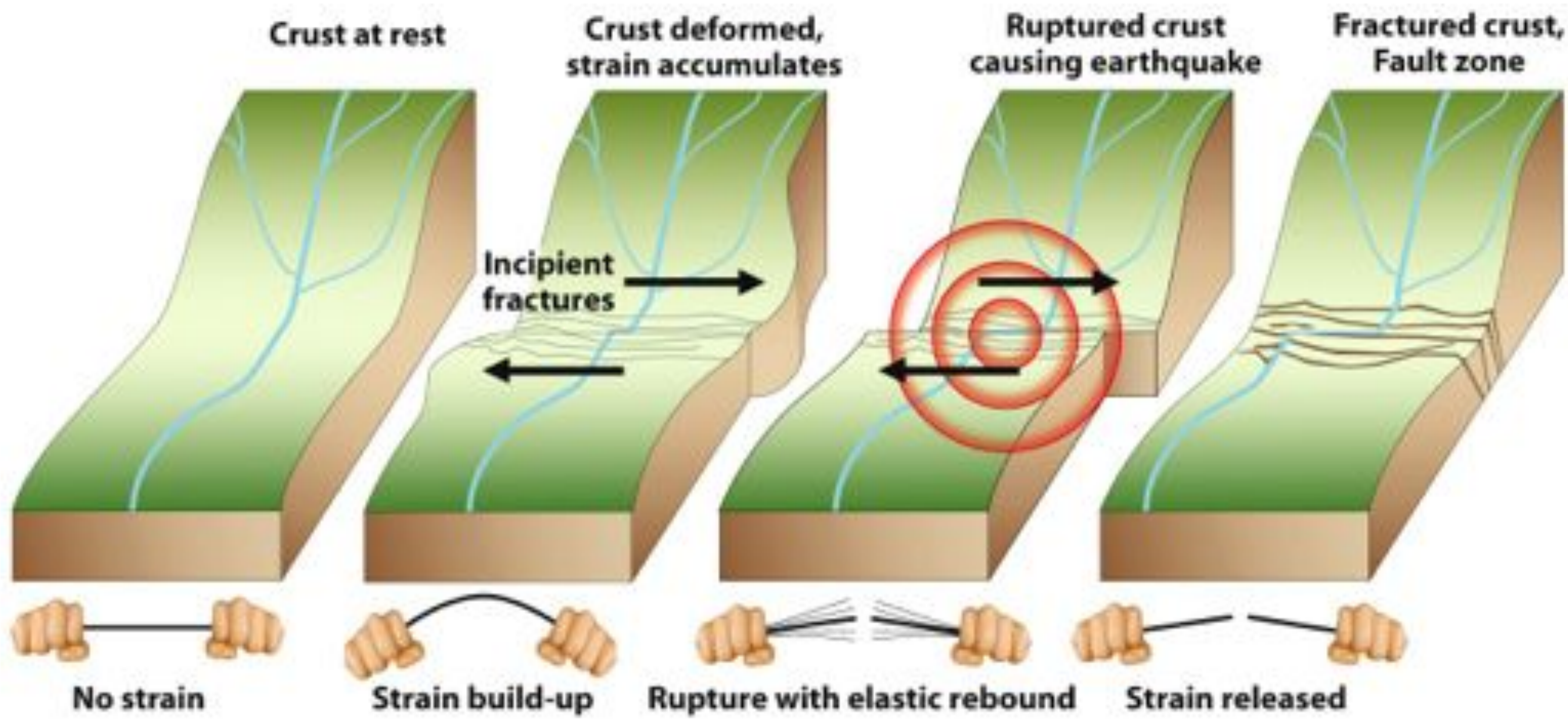
Fault Block Mountains: Tensional Stresses







What Are Earthquakes?



Earthquakes result from slow buildup of elastic strain, and its sudden release – like bending a ruler until it breaks.

Elastic Rebound Theory

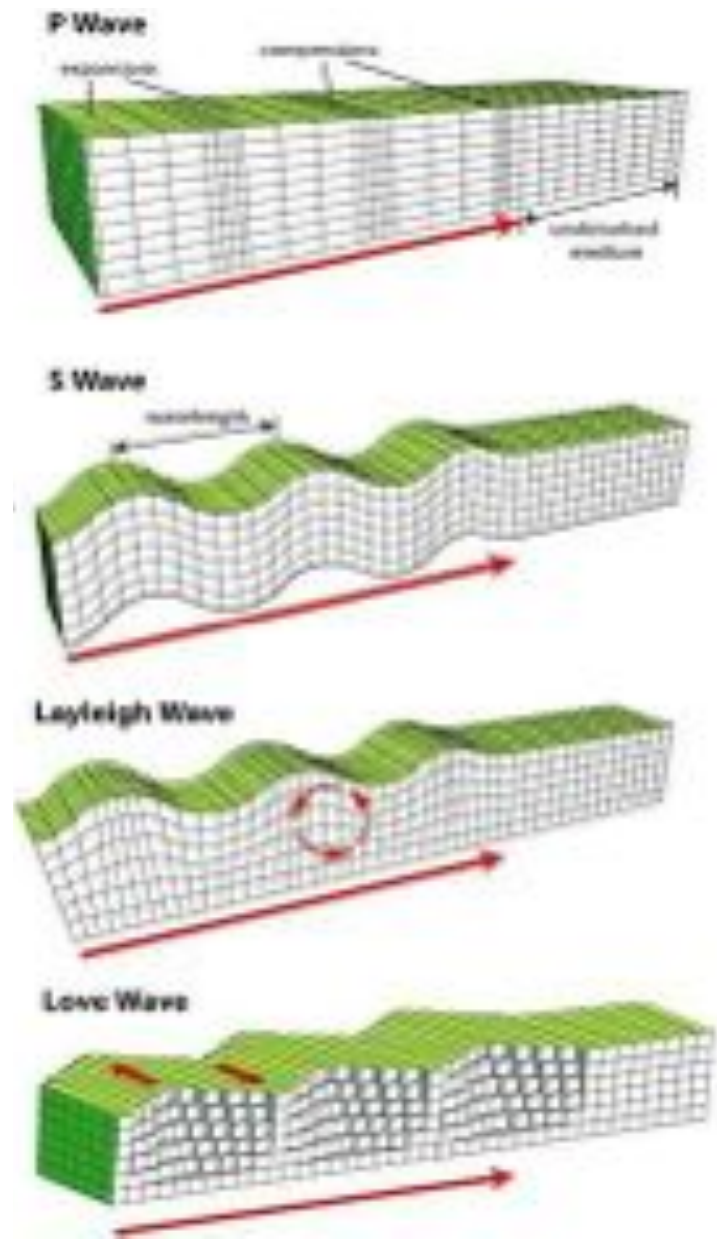
Two Types of Seismic Waves

1. **Body Waves:** travel through the body of the Earth (P & S)

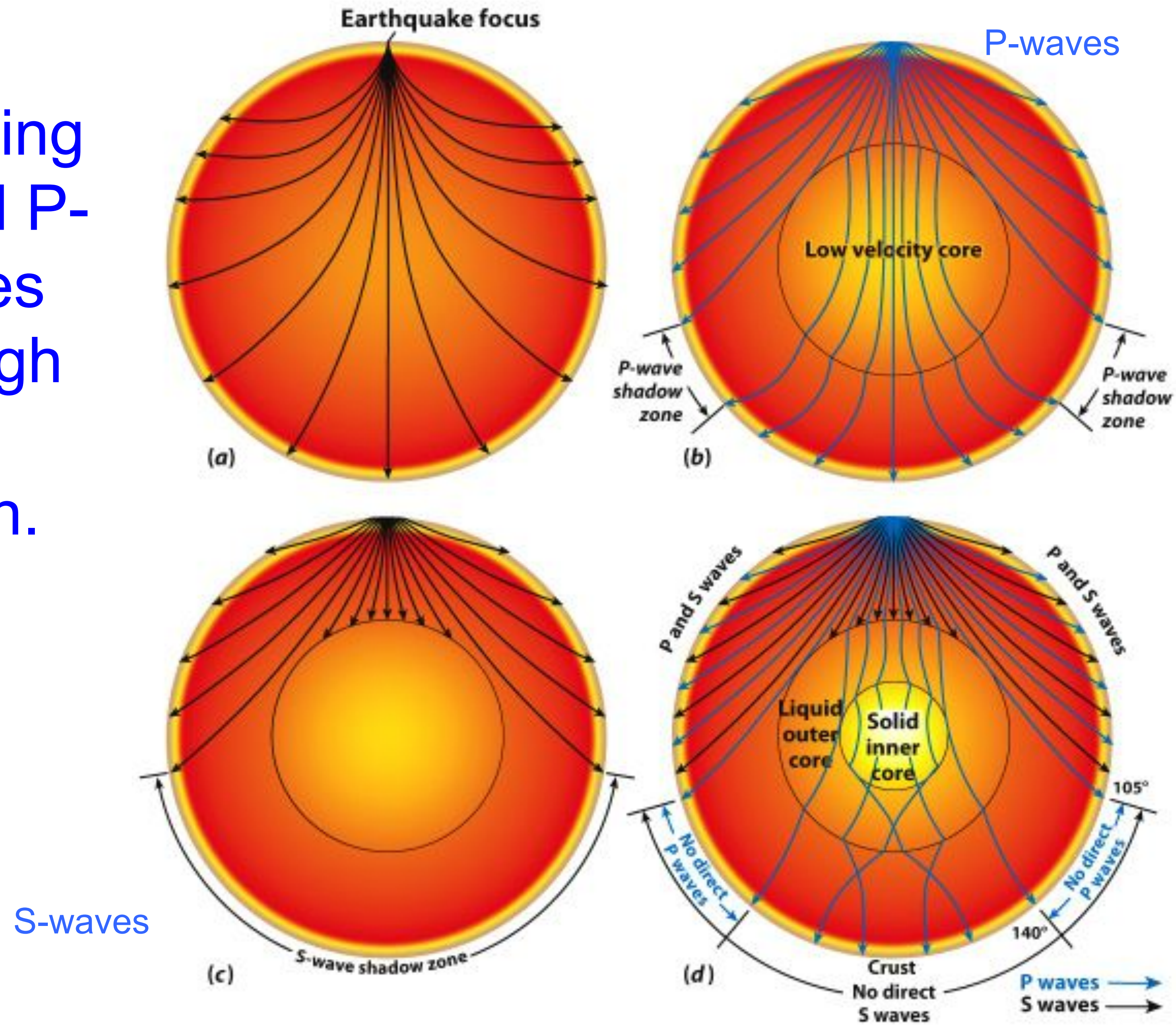
   - Waves compress and pull rocks in the direction of movement,
   - Change the **volume** & **shape** of material

2. **Surface Waves:** travel along the outer layer of the crust (Love and Raleigh)

   - Ground rolls like a water wave
   - Waves travel slowly and cause the most damage.



Traveling S- and P-waves through the Earth.



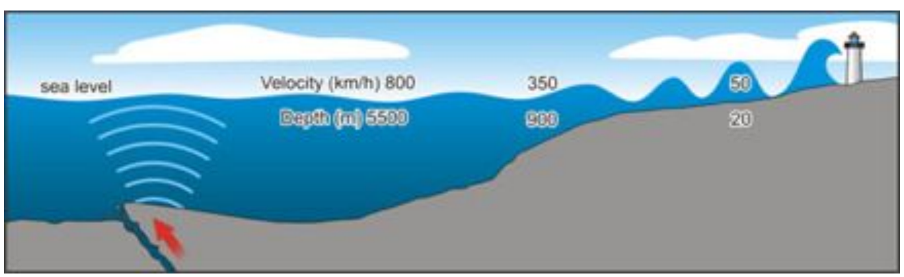
Tsunamis

Tsunamis are NOT tidal waves

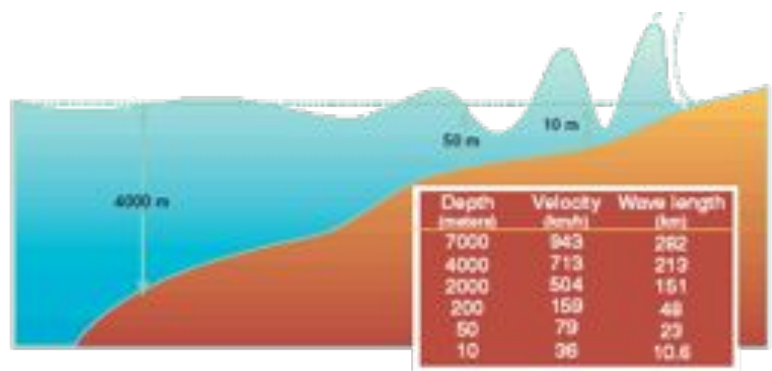
1.

Tsunamis are seismic sea waves caused by earthquakes, landslides, eruptions of island volcanoes.

2.



3.



How old is that rock?

- Relative age: order of events

  Relative dating tells us <u>what order</u> things happened, but not how many years ago they happened.

- Absolute age: age in years

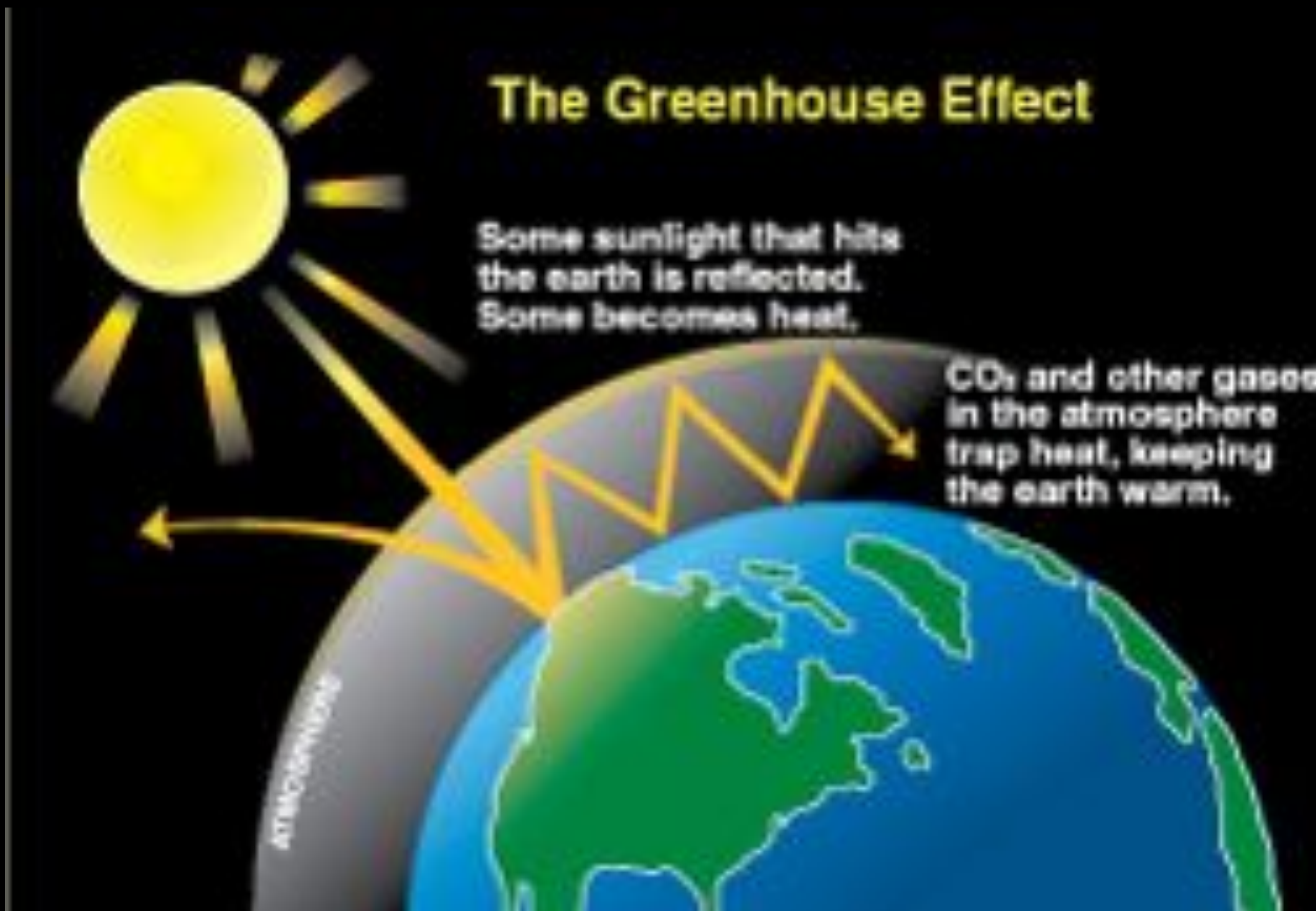
Radioactive Half-Life

- Def.: time it takes for 1/2 of radioactive atoms in a sample to decay

- “Parent” decays to “daughter”
  (potassium-40) (argon-40)

- Potassium-40 half-life
  = 1.3 billion years

The Greenhouse Effect Determines Earth's Heat Budget

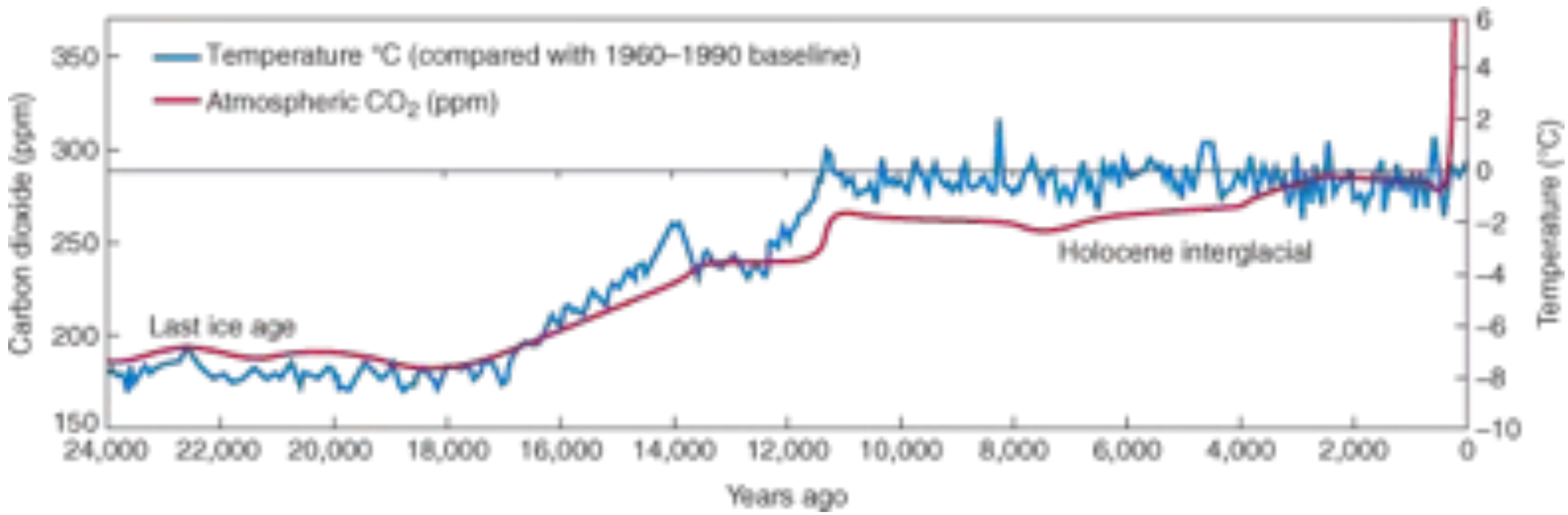


Greenhouse Gases

Carbon Dioxide: Most abundant, long-lived
Methane: Powerful greenhouse gas, short-lived
CFCs: Being phased out
Ozone: Very short lived
Nitrous Oxide: Increasing

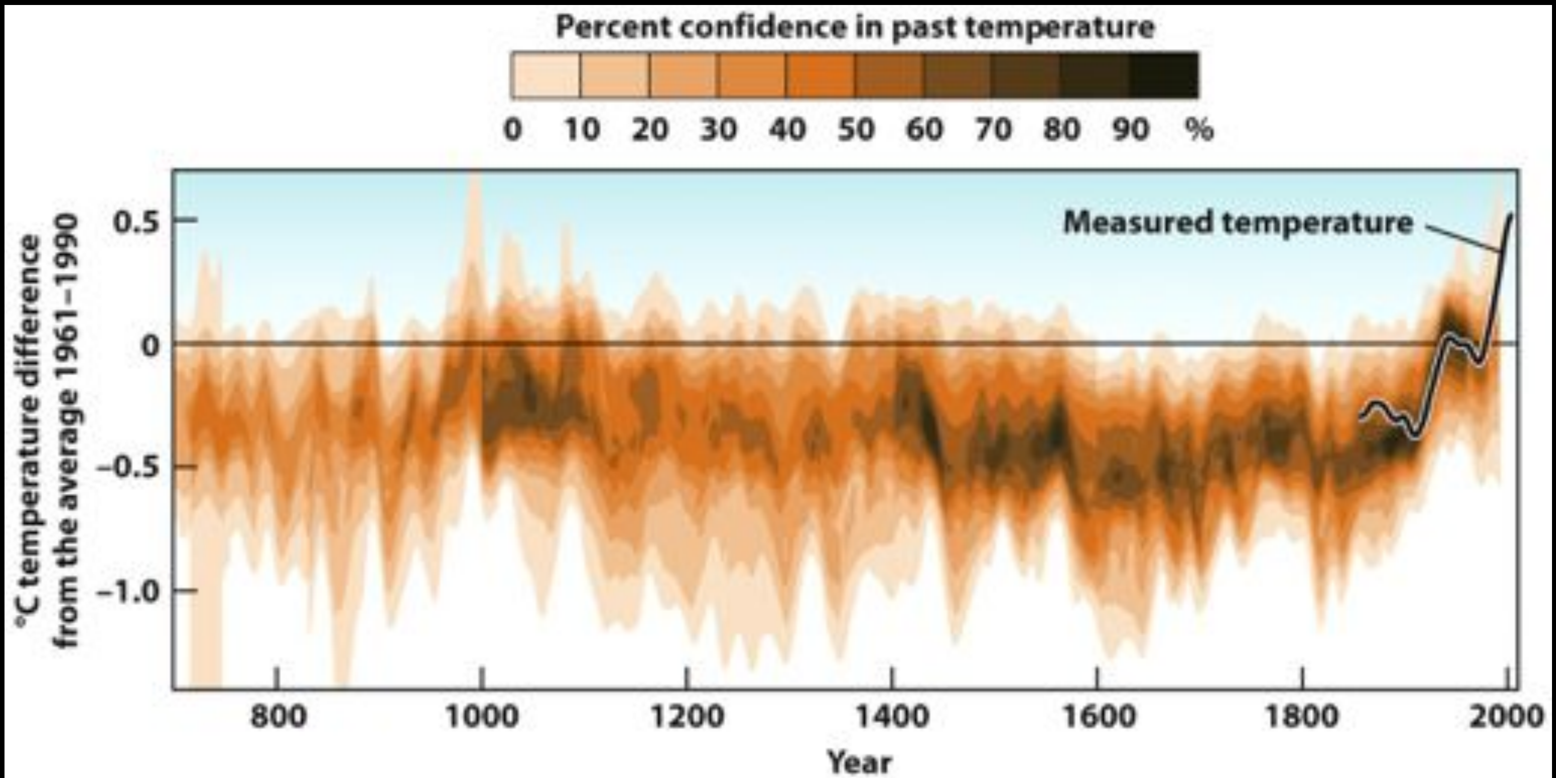
The Ice Ages

- Caused by changes in **solar radiation**
- Changes in atmospheric carbon dioxide **were caused by** the temperature changes.



Earth's atmospheric temperature has risen by about 0.9°C in the past 100 years.

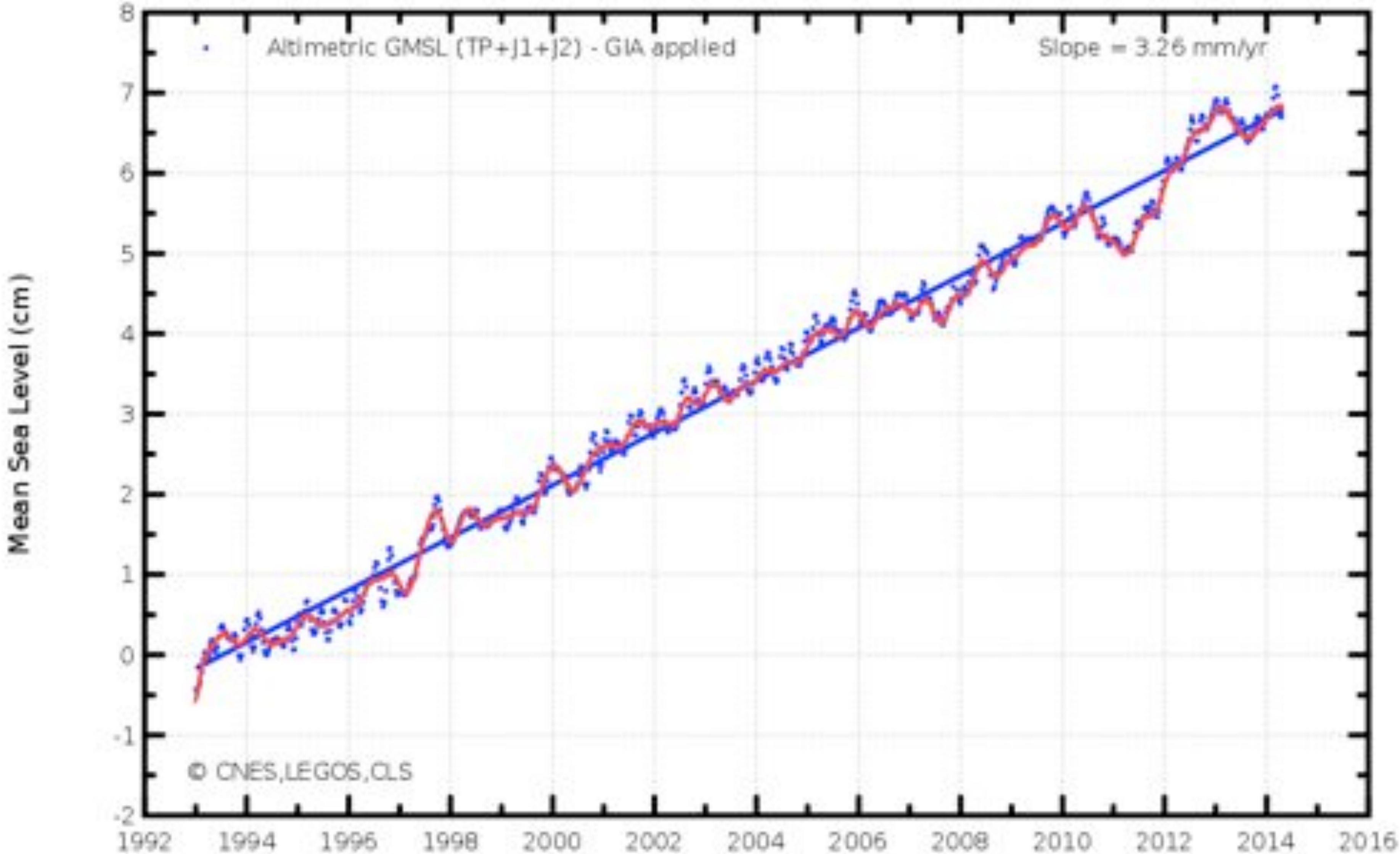
- Atmospheric CO_2 is greater now than it ever has been in the past ? Yrs
- Earth is warmer now than at any time in the past 1,300 years.



Climate Change 2007: The Physical Science Basis. Working Group I Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Figure 6.10. Cambridge University Press

Figure 14.19

Global Sea Level Rise



A glacier is a river of ice.

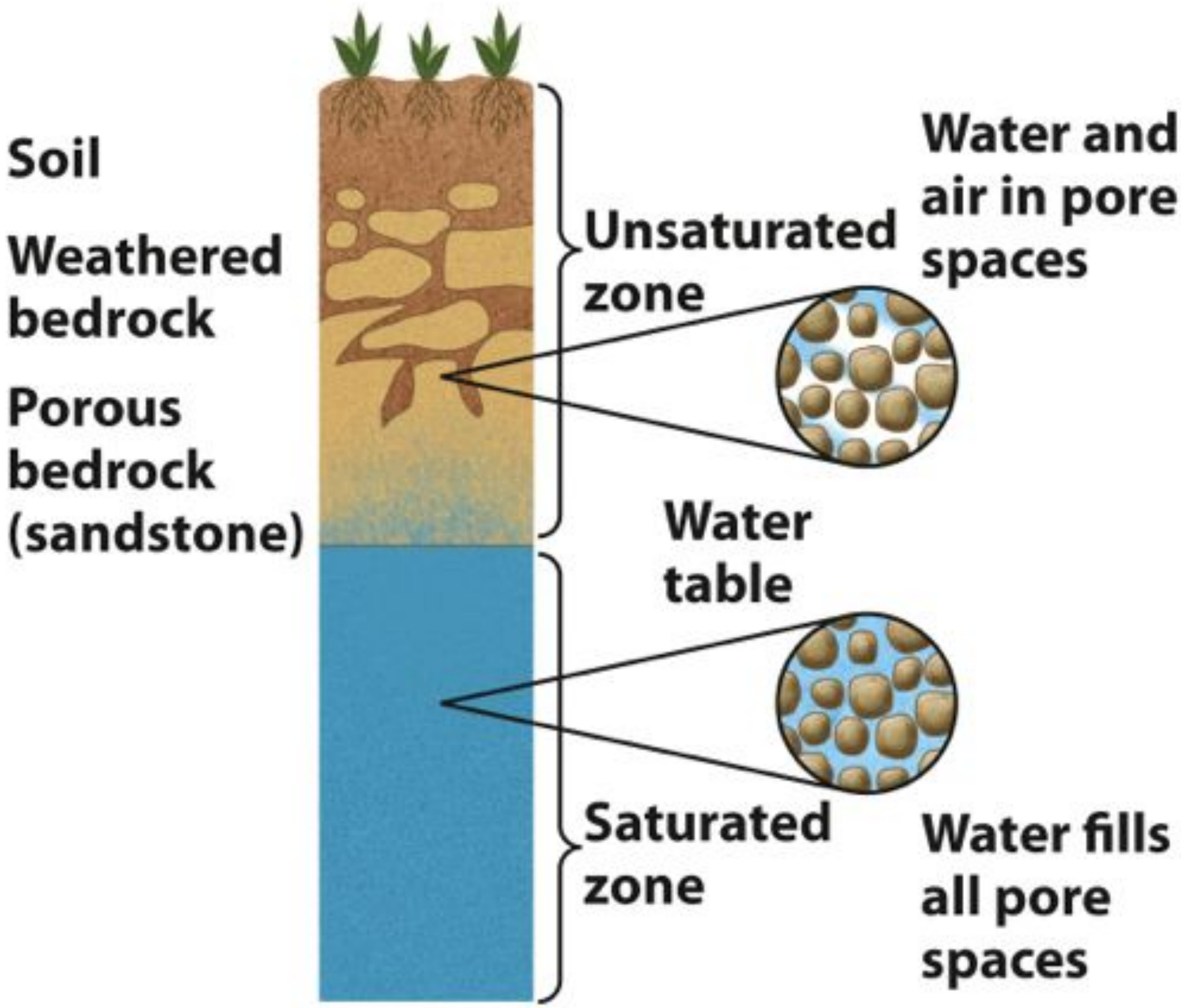
Glaciers can range in size from:

100s of m
(mountain glaciers)
to
100s of km
(continental ice sheets)

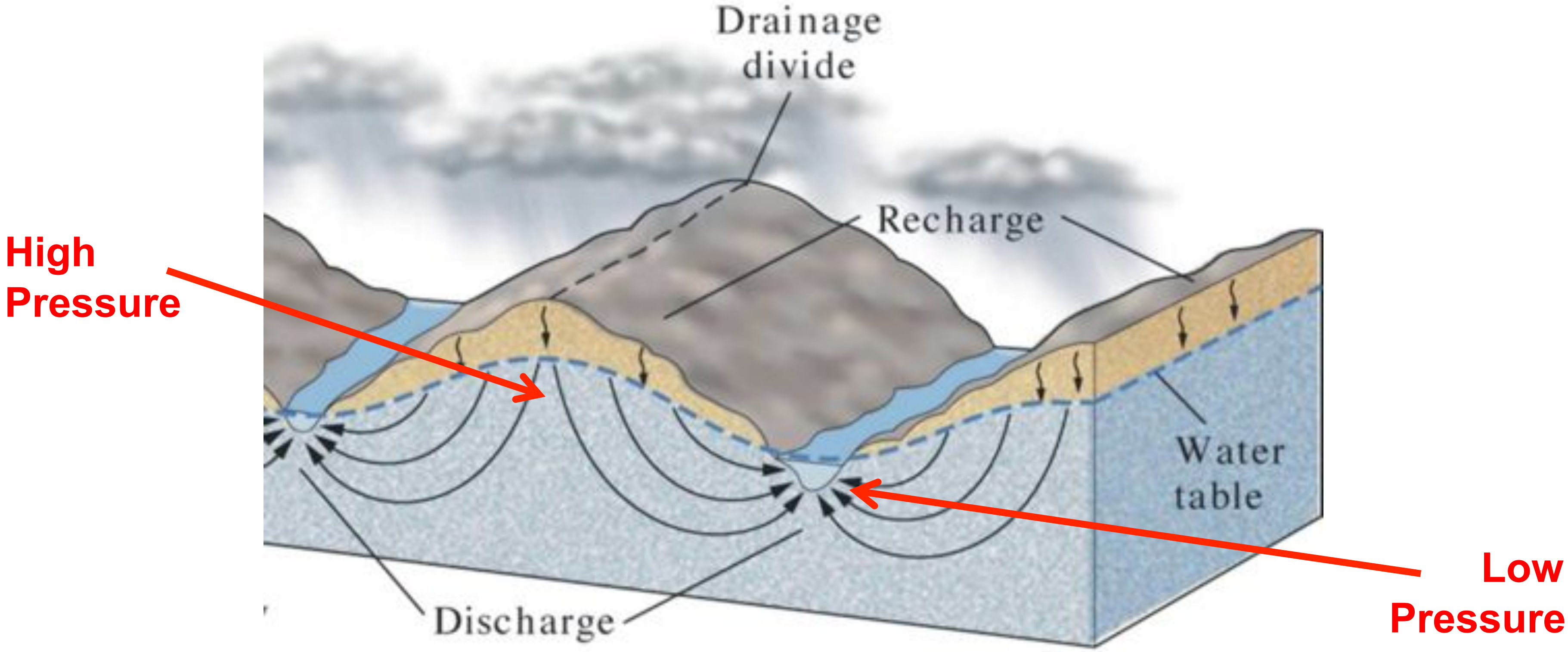
Most glaciers are 1000s to 100,000s of years old!

	Total Water	Fresh Water
Oceans	96.6%	
Ice	1.7%	69.6%
Groundwater	1.7%	30.1% (more than half is salty)
Rivers & Lakes	0.007%	0.27%

Groundwater is found where the crust is porous



Groundwater flows in response to gravity and hydraulic pressure

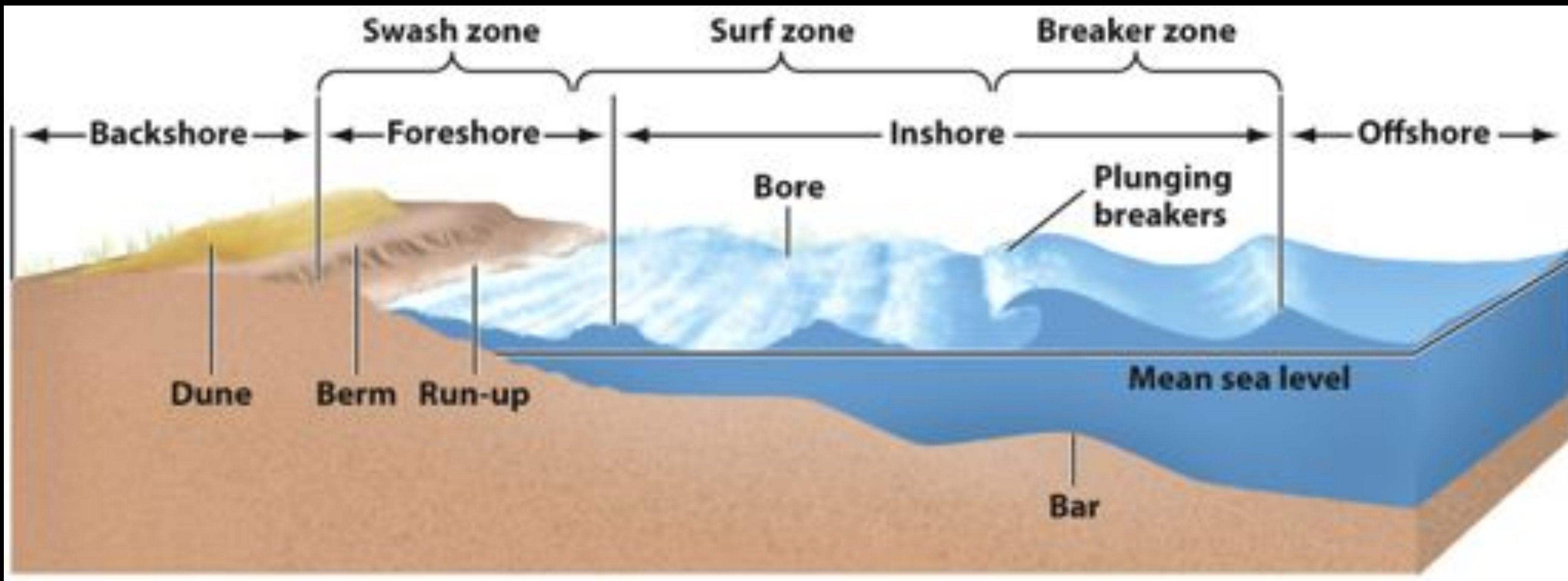


Velocity of flow ranges from m/day to cm/century

- Depends on pressure gradient (slope of water table)
- Depends on **permeability** of the rocks

Coastal processes are driven by:

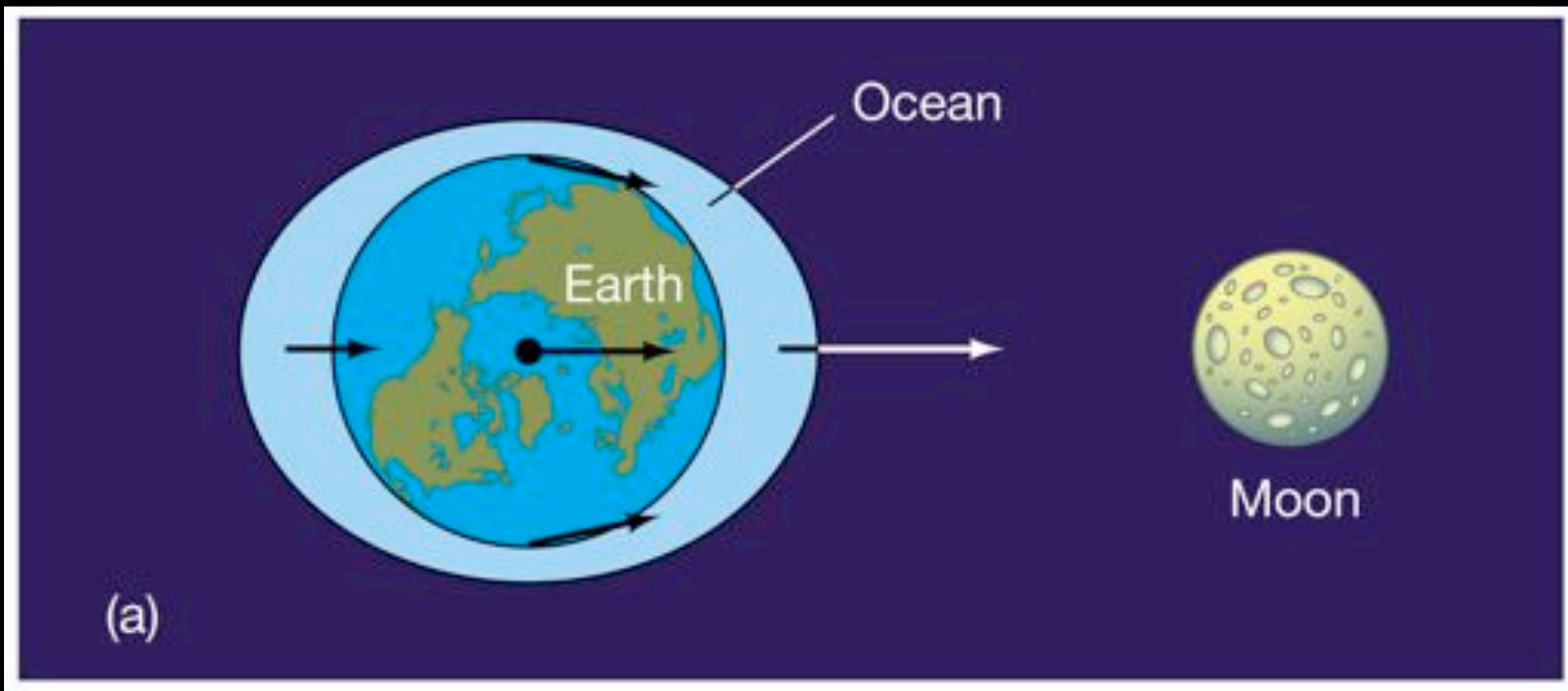
wind, waves, tides, sea-level change, & currents



The coastal zone is a dynamic environment that is constantly changing

Lunar Tide

- Gravitational pull from the Moon
- Gravity and Earth's rotation create two tides every day



Five Recognized Oceans

Average ocean depth is 3800 m
(about the length of Manoa Valley)

TABLE 23.1 Oceans

Ocean	Area (km²)	Average Depth (m)	Greatest Depth (m)
Pacific Ocean	166,240,977	4,637	Mariana Trench: 11,033 m deep
Atlantic Ocean	86,557,402	3,926	Puerto Rico Trench: 8,605 m deep
Indian Ocean	73,426,163	3,963	Java Trench: 7,725 m deep
Southern Ocean	20,327,000	4,000 to 5,000	Southern end of the South Sandwich Trench: 7,235 m deep
Arctic Ocean	13,224,479	1,204	Eurasia Basin: 5,450 m deep

Ocean Currents

Surface Currents

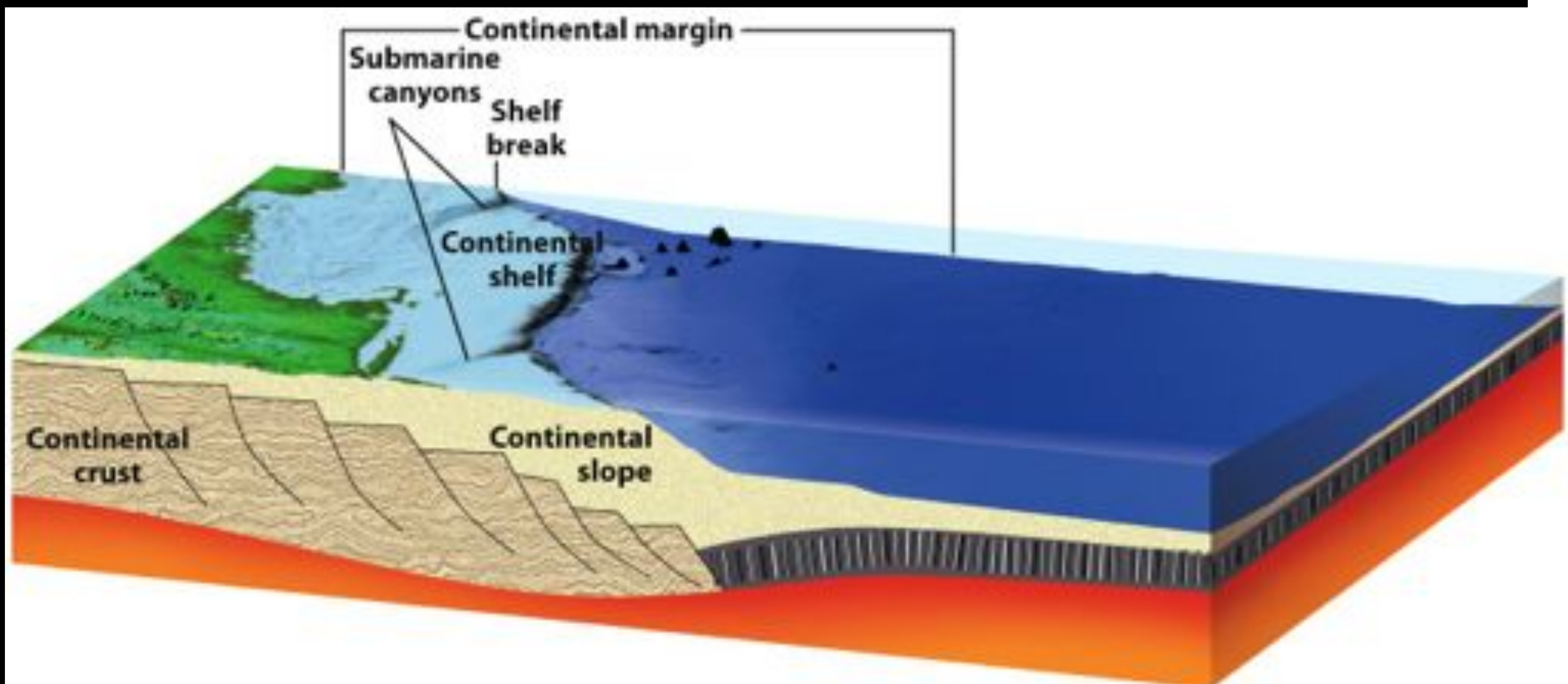
- Driven by prevailing winds
- The **Coriolis Effect** turns currents right in the north and left in the south
- Circulation forms 5 **Gyres** in the ocean basins
- The gyres circulate heat.

The Continental Margin

Continental Shelf: the flat, submerged edges of continents

Continental Slope: the sloping edges of continental shelf

Continental Rise: transition from continental to oceanic crust

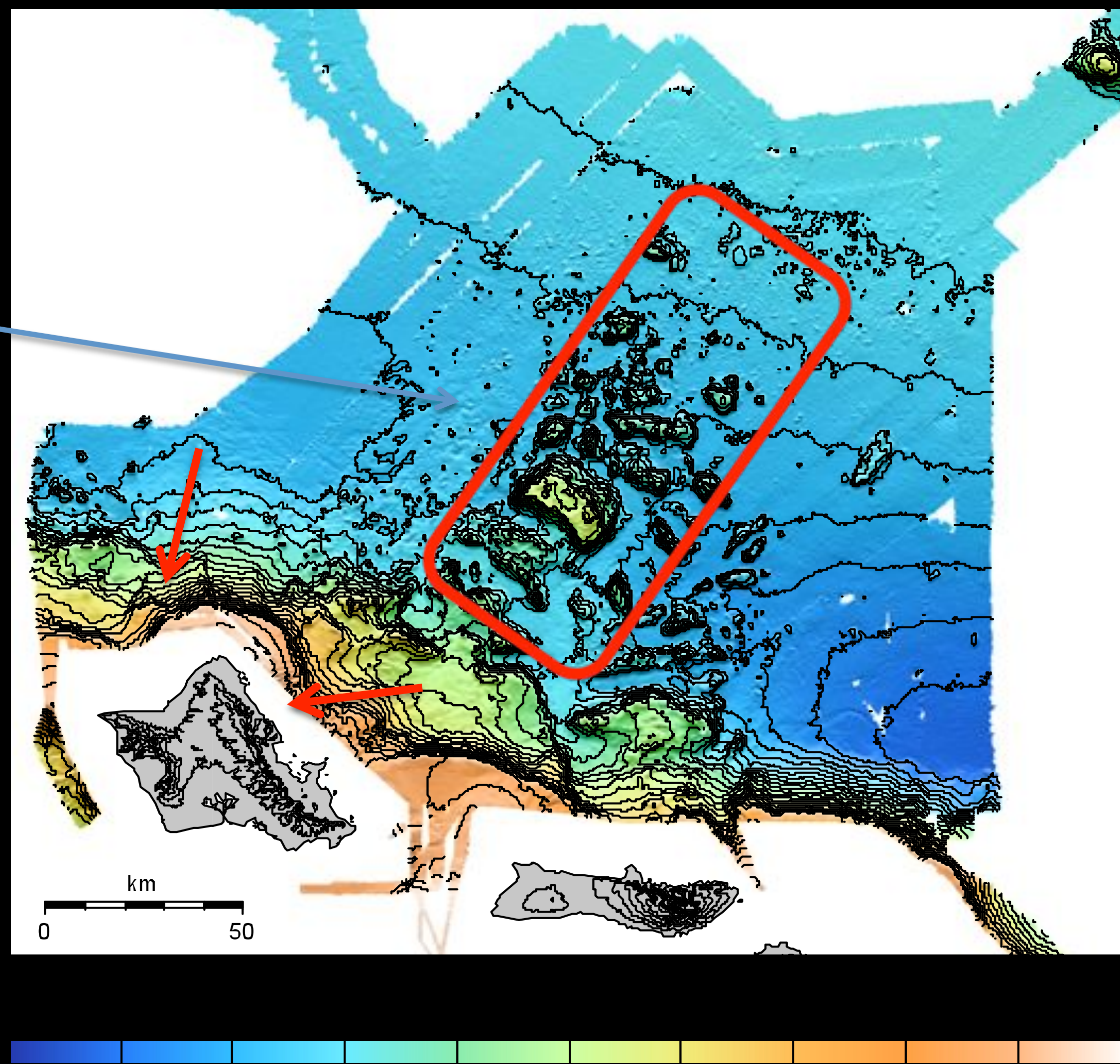


Nuʻuanu landslide ~ 2 Million years ago

Big gap in flank, large “bumps” on the seafloor

Largest (Tuscaloosa) is multiple miles across, >> thousand ft tall

Debris stretches nearly 100 miles



Slide by J. Sinton

Other landslides around the islands

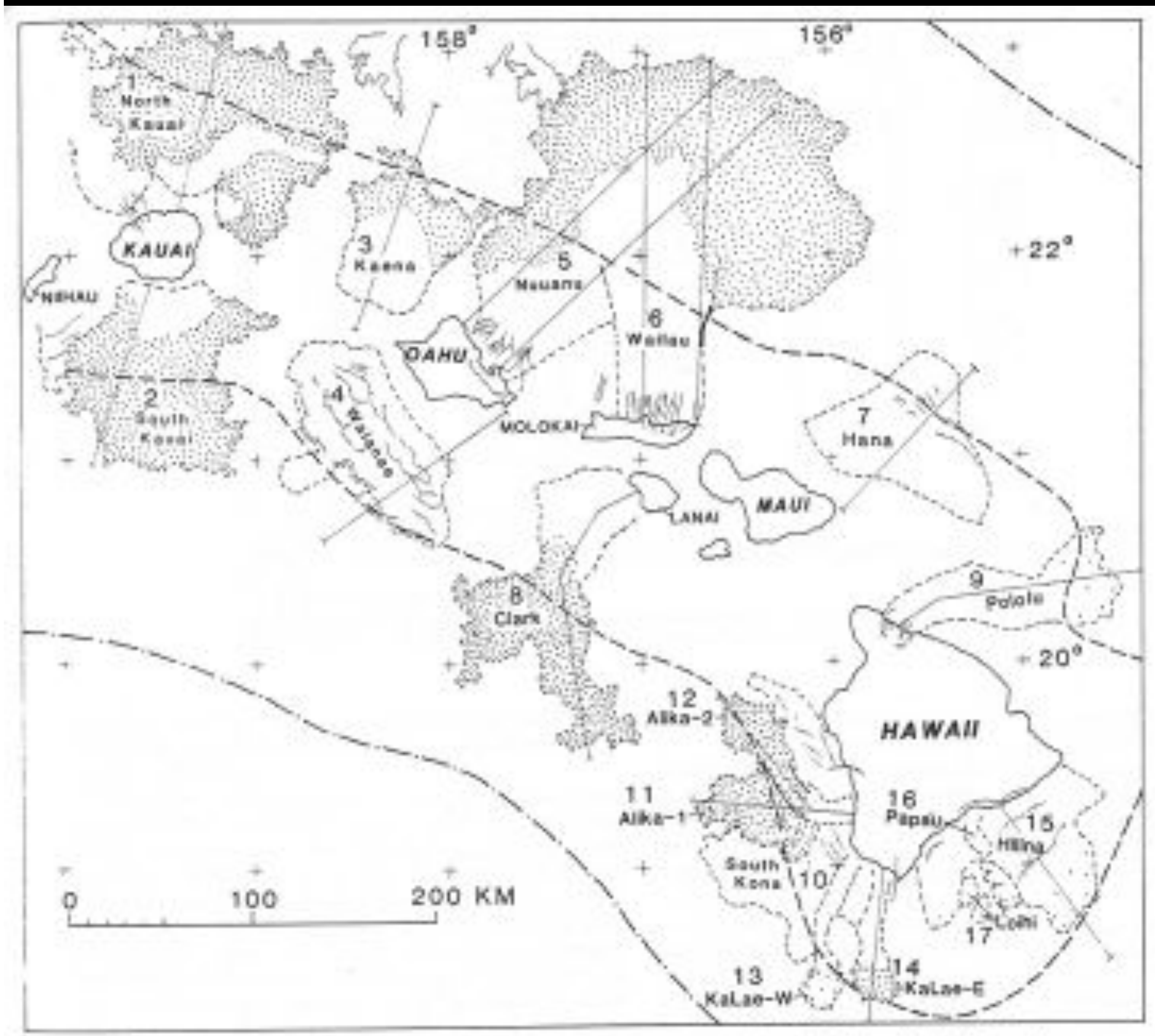


Fig. 2. Map of southeastern Hawaiian Ridge showing major slides bounded by dashed lines identified by number in text and Table 1; compare with Figure 1. Dotted area, hummocky ground (widely spaced where subdued); hachured lines, scarps; thin, downslope-directed lines, submarine canyons and their subaerial counterparts; heavy dashed line, axis of the Hawaiian Deep; dash-dotted line, crest of the Hawaiian Arch.

17 large landslides in principal Hawai‘i region

Represents ~6 million yrs (= 1 every 350,000 yrs)

Two Kinds:

1. slumps (prolonged, progressive formation)

2. catastrophic debris avalanches

Debris avalanches are likely to produce huge tsunami locally, but
Would tsunami be Pacific-wide?

GG101 Final Exam Review

- Final Exam info:
  - Tuesday, December 15th 12-2pm
  - 100 multiple choice/true-false questions
  - Covers material from all lectures (comprehensive)
  - 1 hand-written page "cheat sheet" allowed (double-sided ok)
  - Things to help you study:
    1. Lecture notes (posted on web)
    2. Old midterms and practice exams (posted on web)
    3. Homework assignment questions
    4. Assigned reading