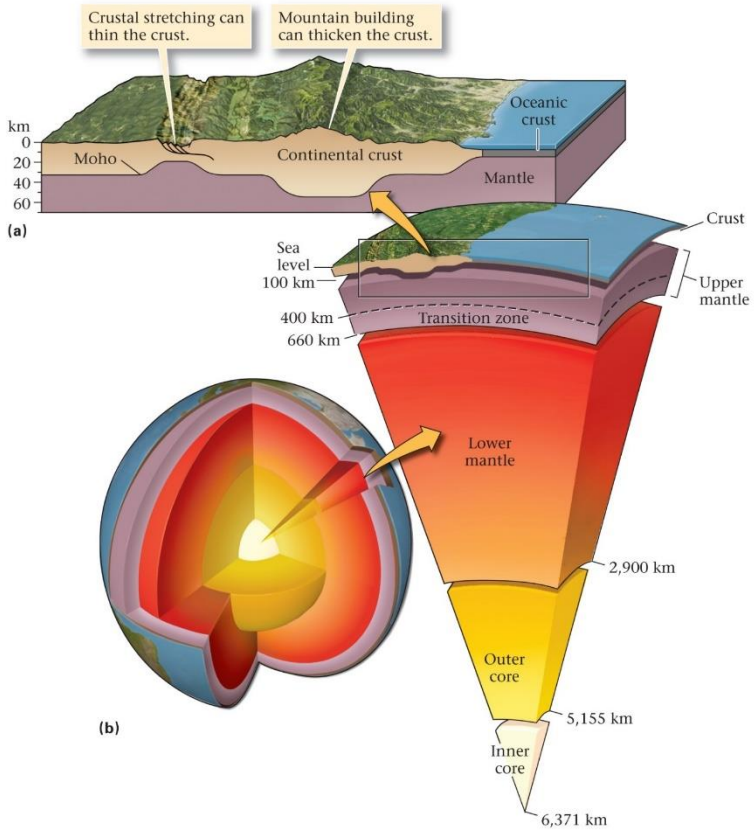
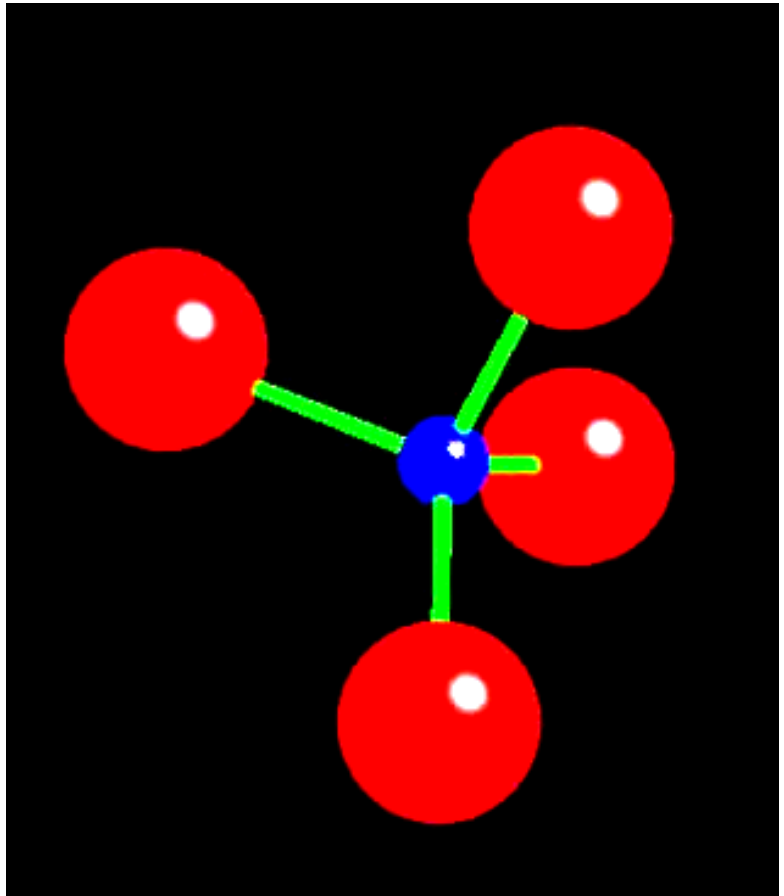
Violent Earth

2. The Materials of our Layered Earth

Structure → Chemistry → Rocks

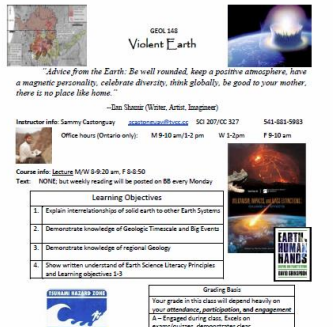


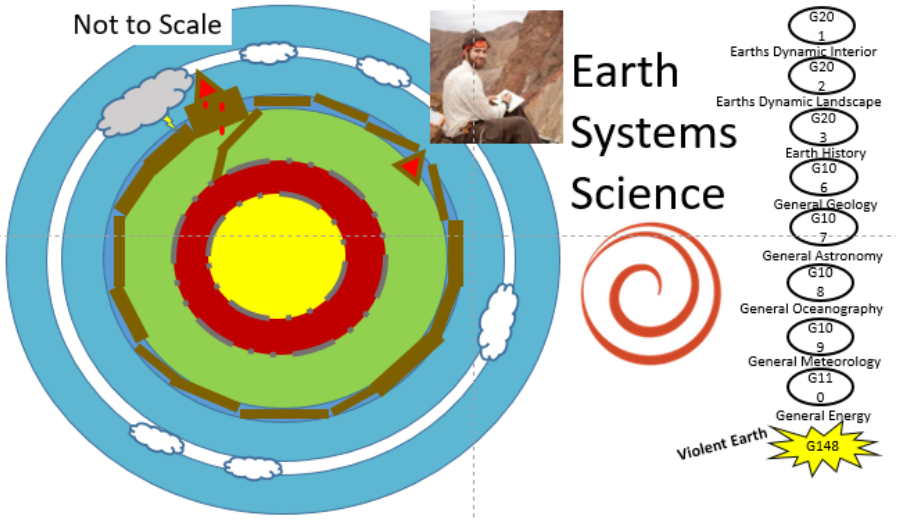


Violent Earth

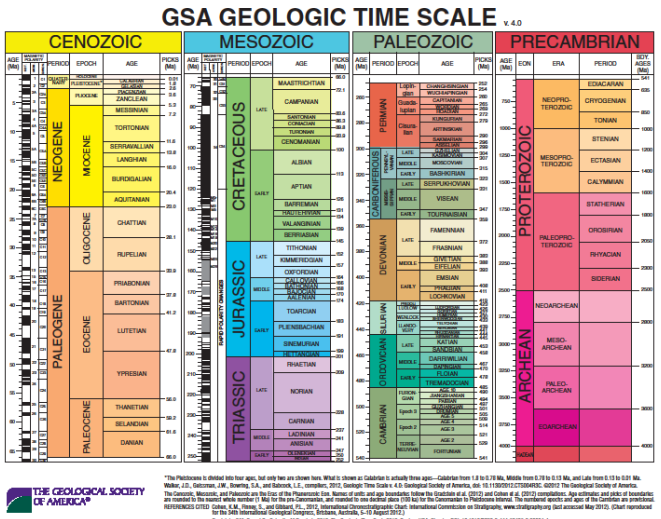
1. The Systems of Our Violent Earth

Natural Violence → TVCC Classes → Deep Time

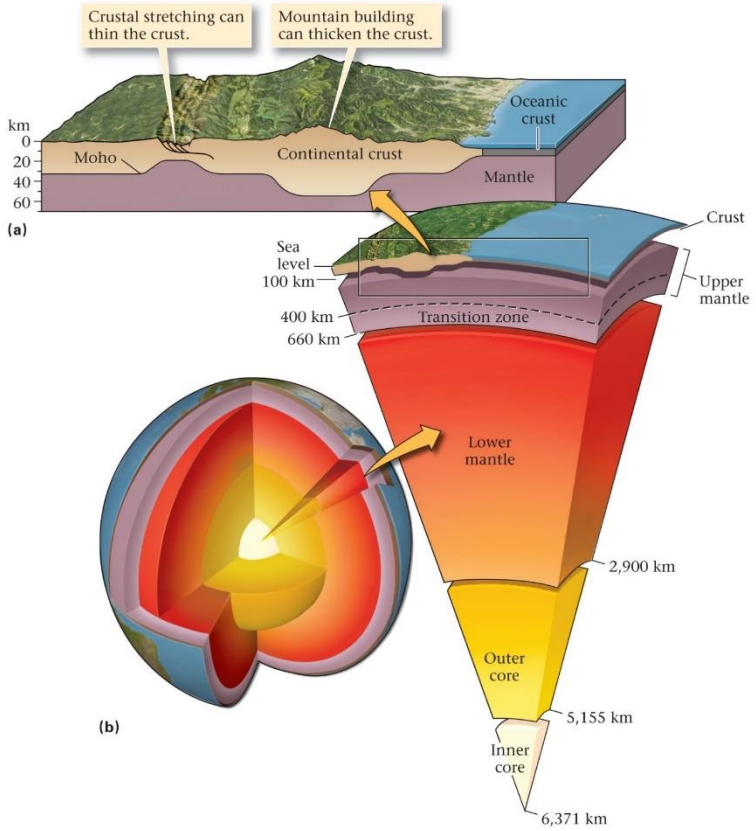


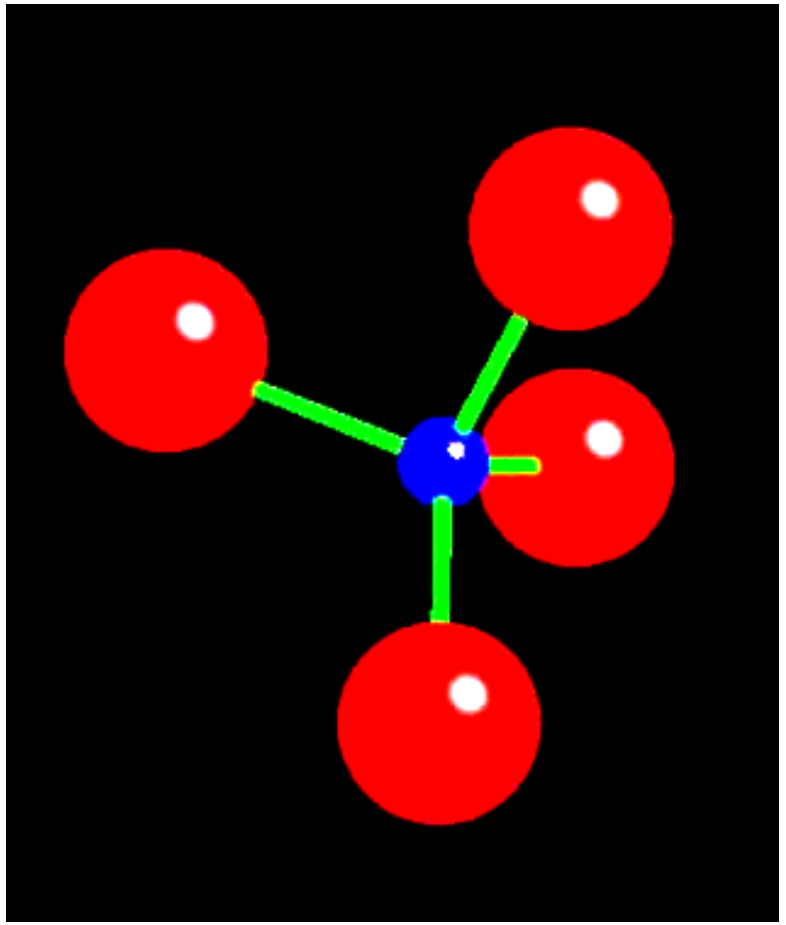


Here is Today

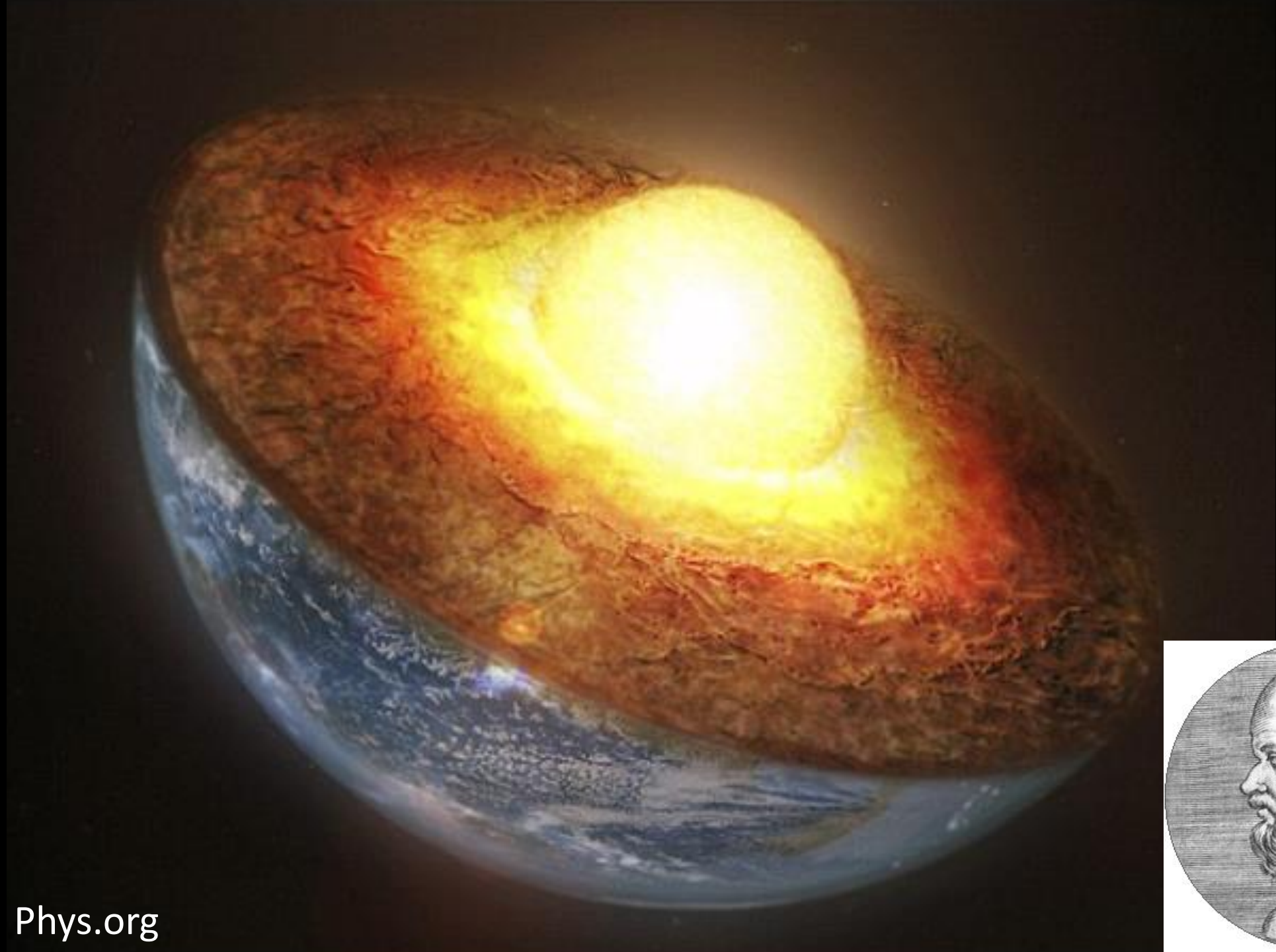


Structure → Chemistry → Rocks



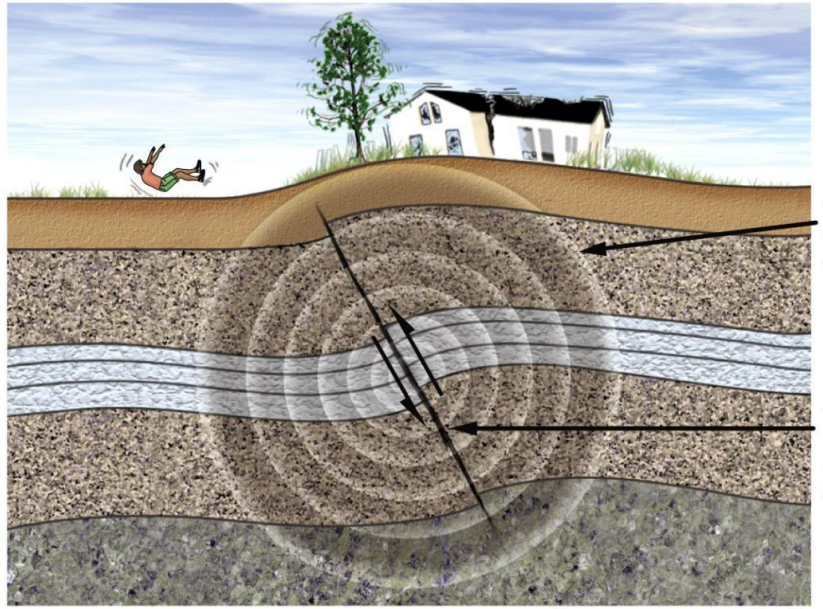


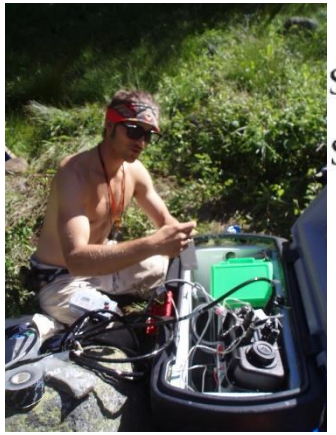
This is an Introduction, NOT COMPREHENSIVE

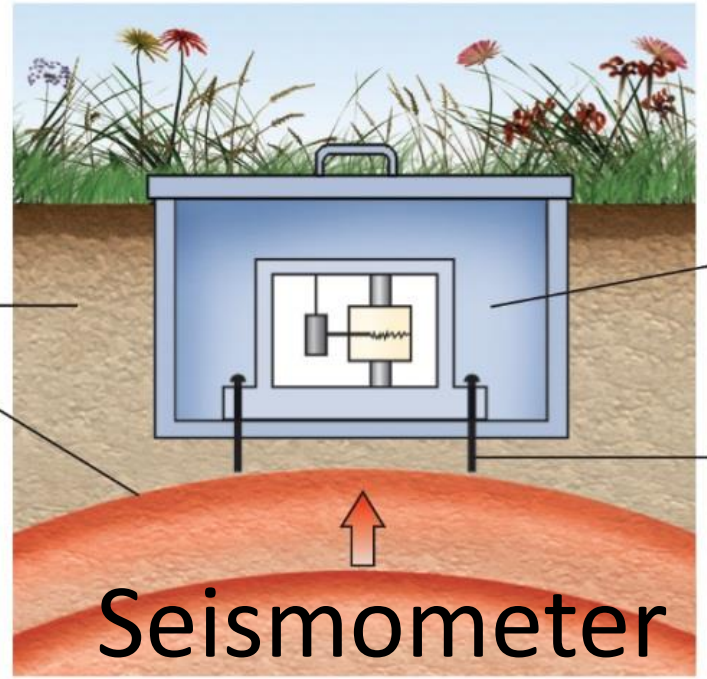


Phys.org

Seismology

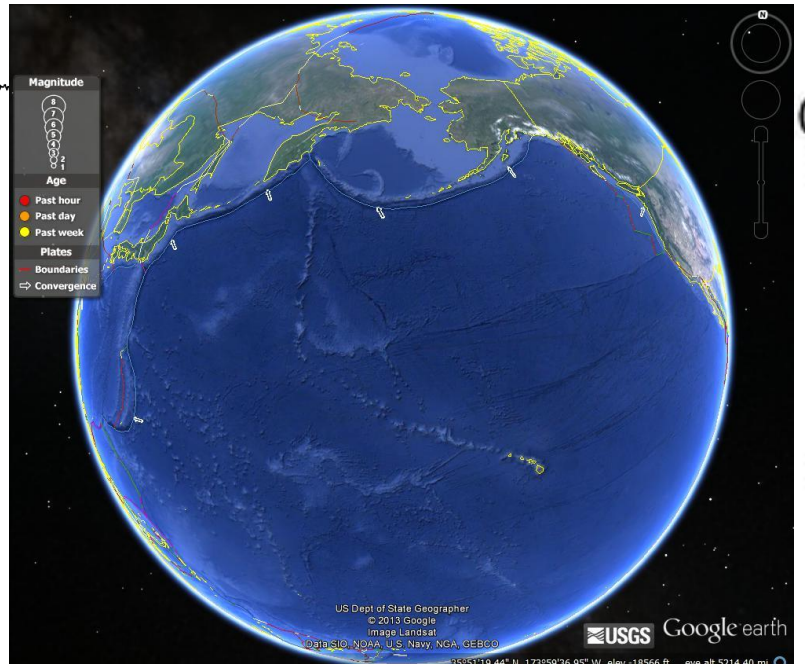


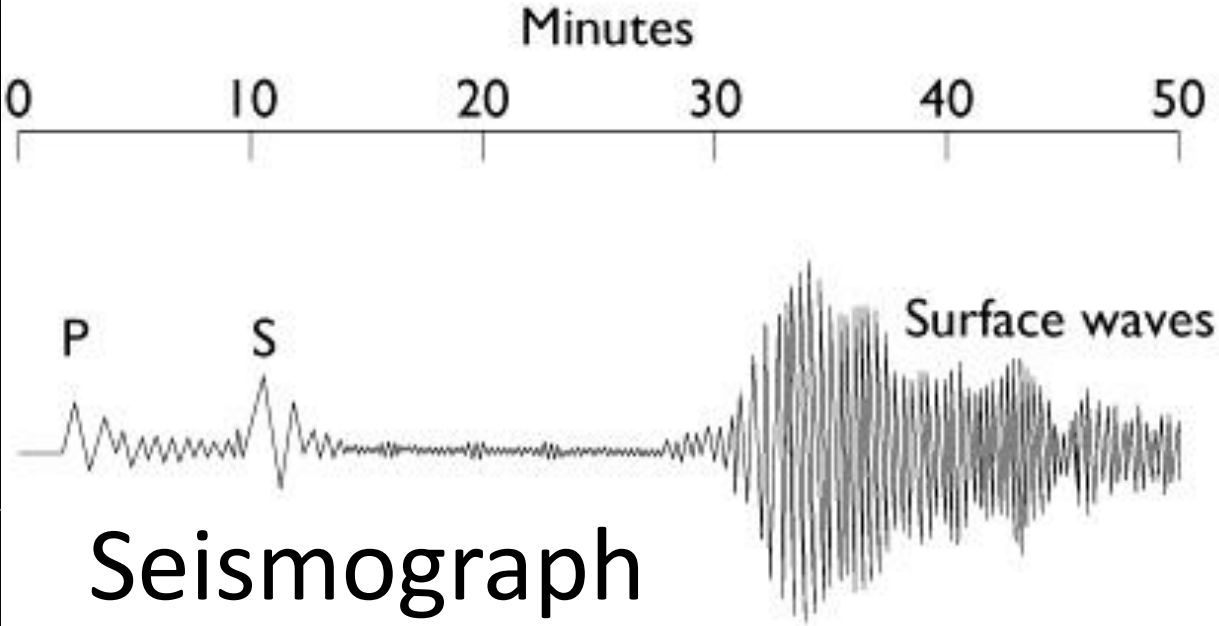




Seismometer

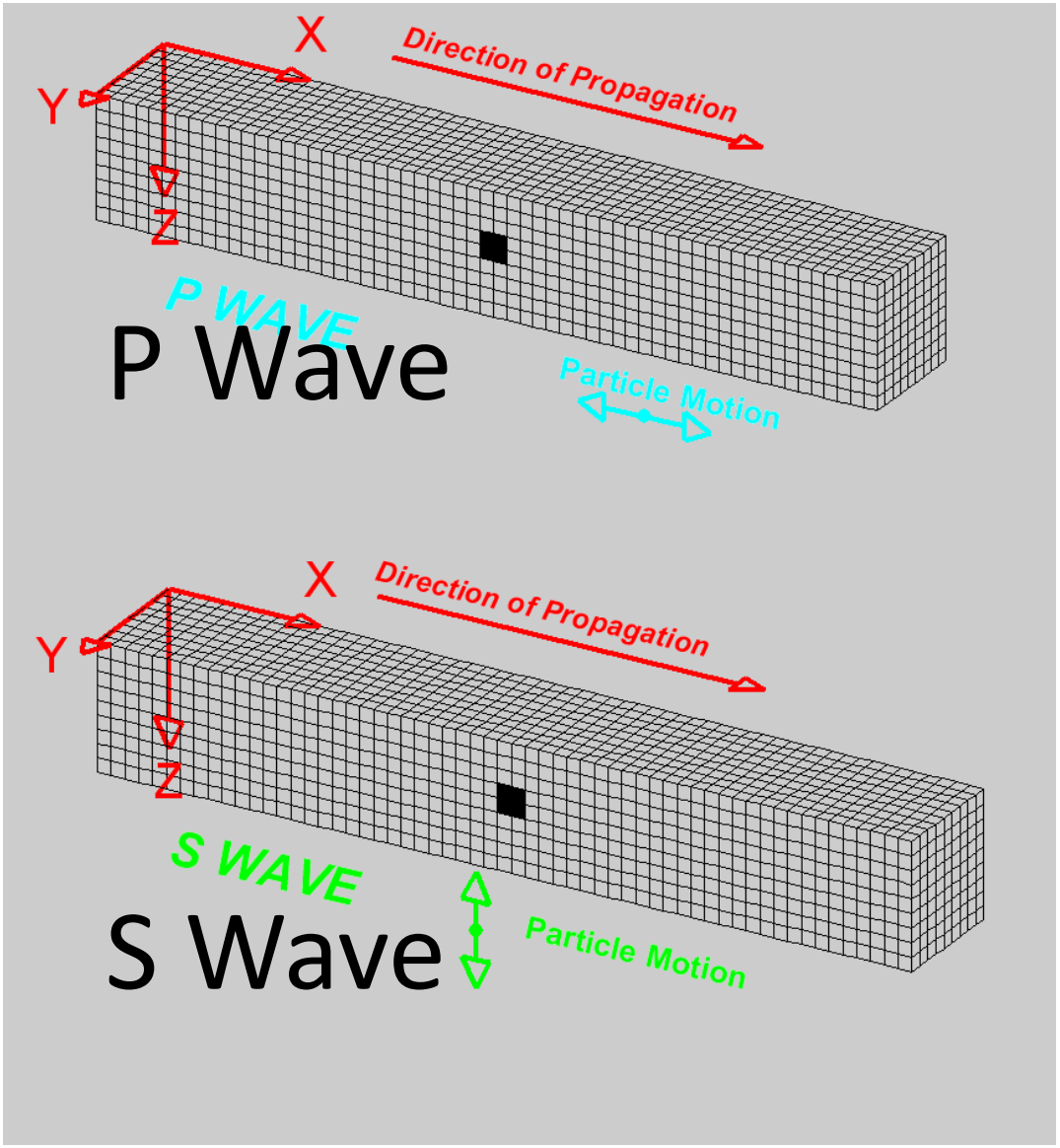
PNSN
Pacific Northwest Seismic Network





Seismograph

Seismic Waves

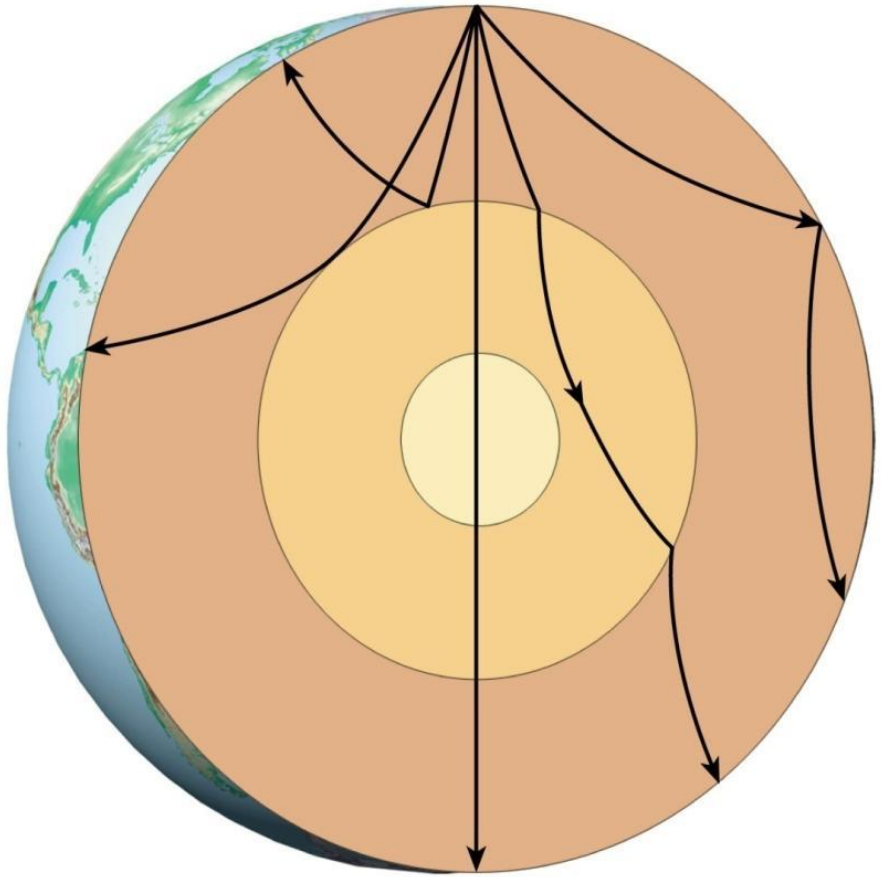


The **velocity** of seismic waves depend on the **material properties** of the rock through which they move

Waves move **faster** through more **dense** material

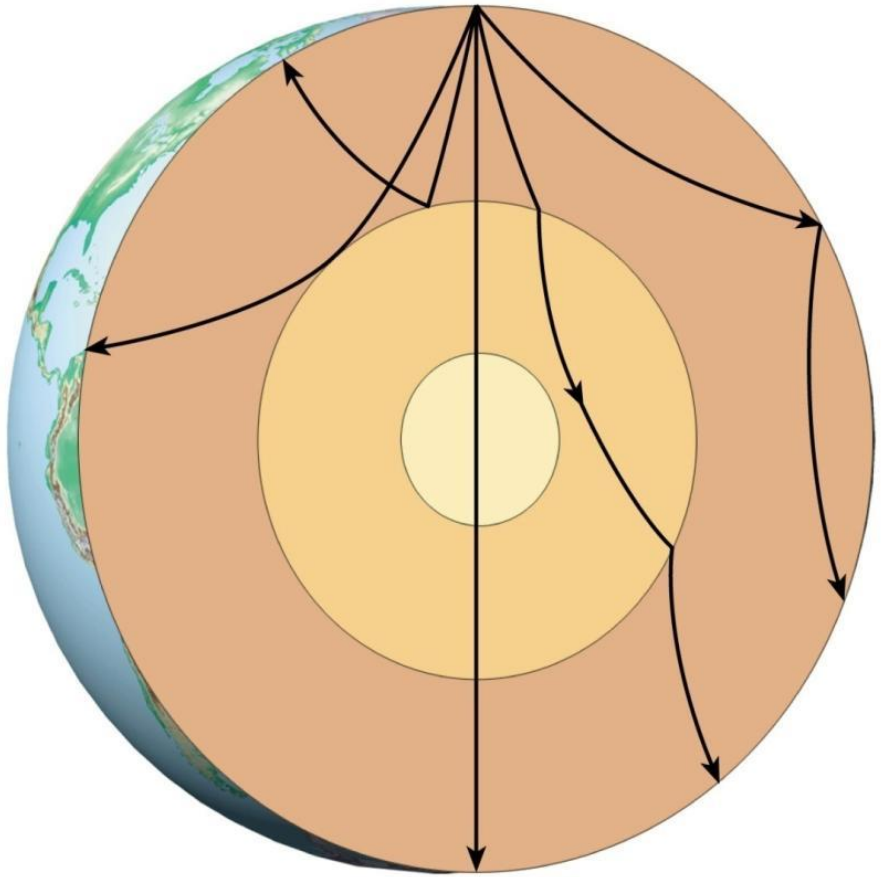
Waves move **slower** through **hotter** material

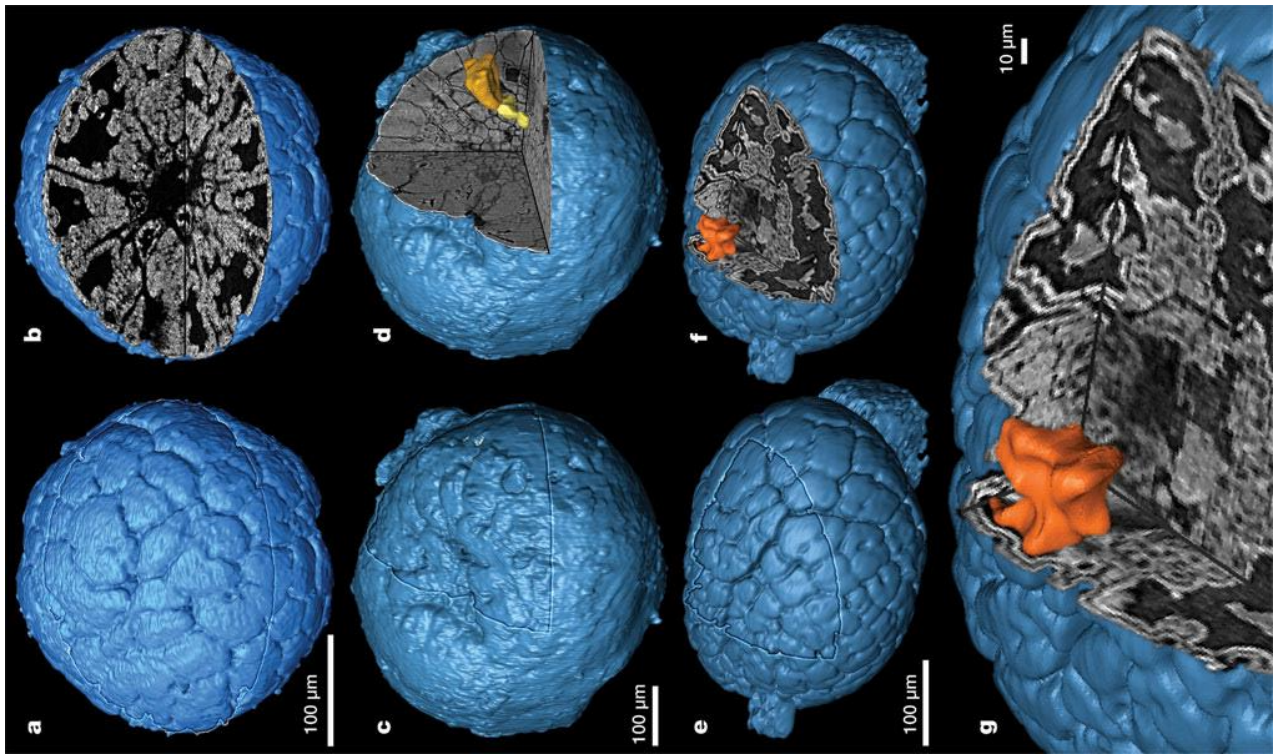
By comparing seismic wave arrival times to our *model* of the earth, seismology has illuminated the layered Earth!



By comparing seismic wave arrival times to our *model* of the earth, seismology illuminated the layered Earth! [Harold Jeffreys, 1926]

Tomography

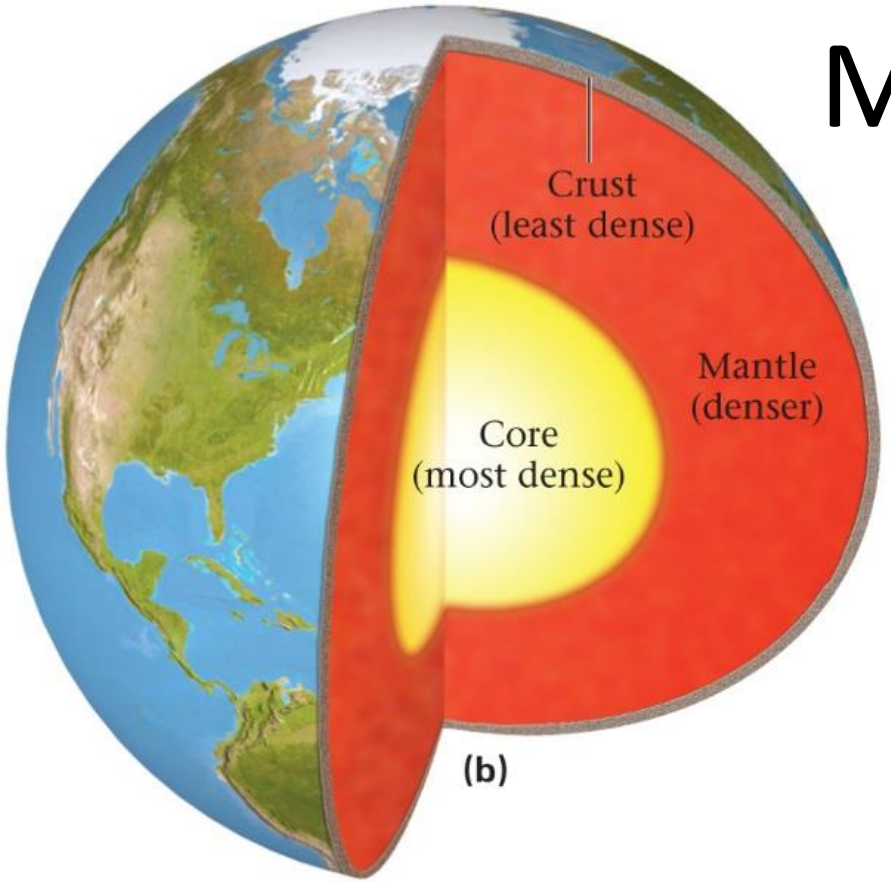




Layers of the Earth:

Compositional –

Core, Mantle, Crust



Mechanical –

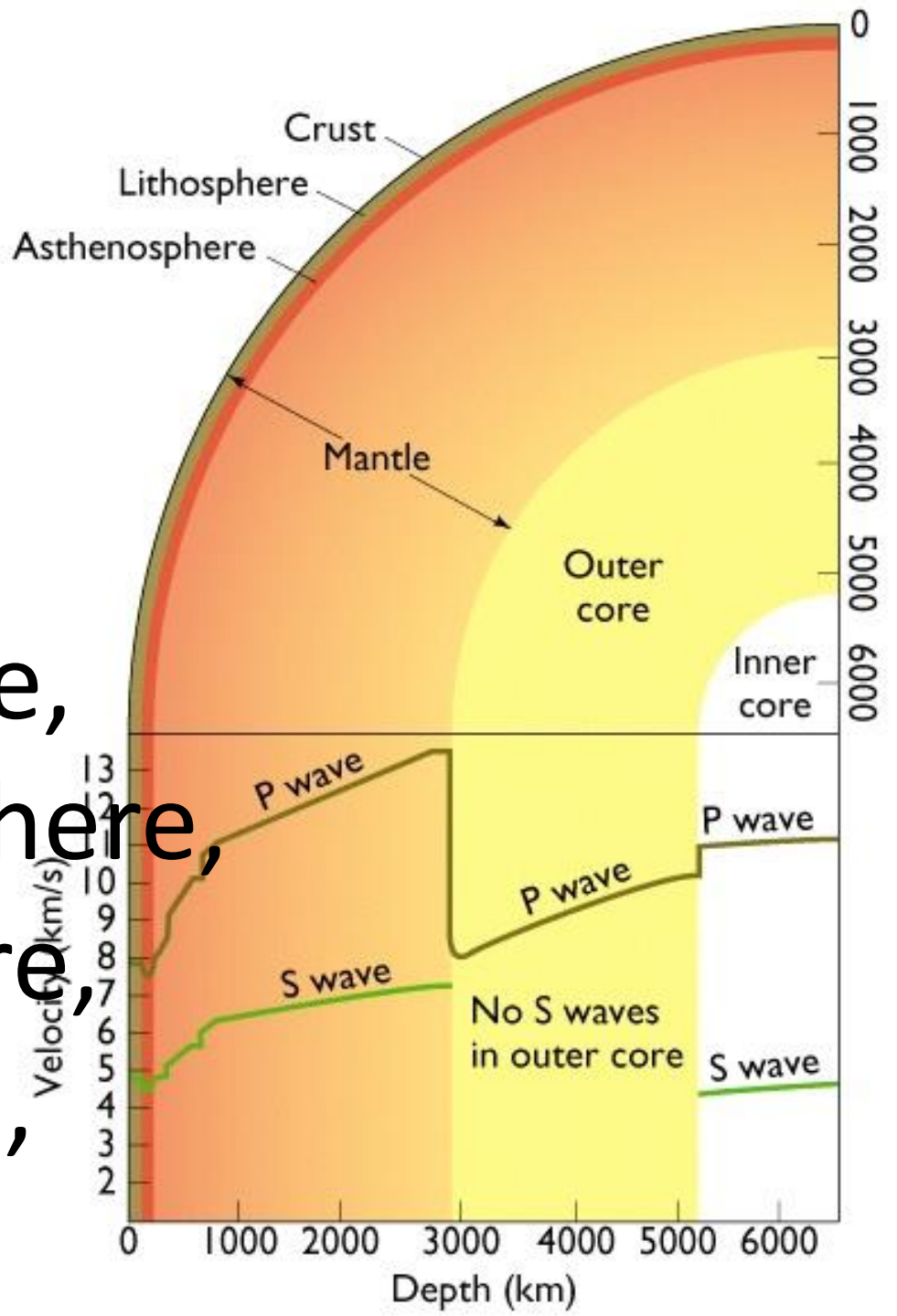
Lithosphere,

Asthenosphere,

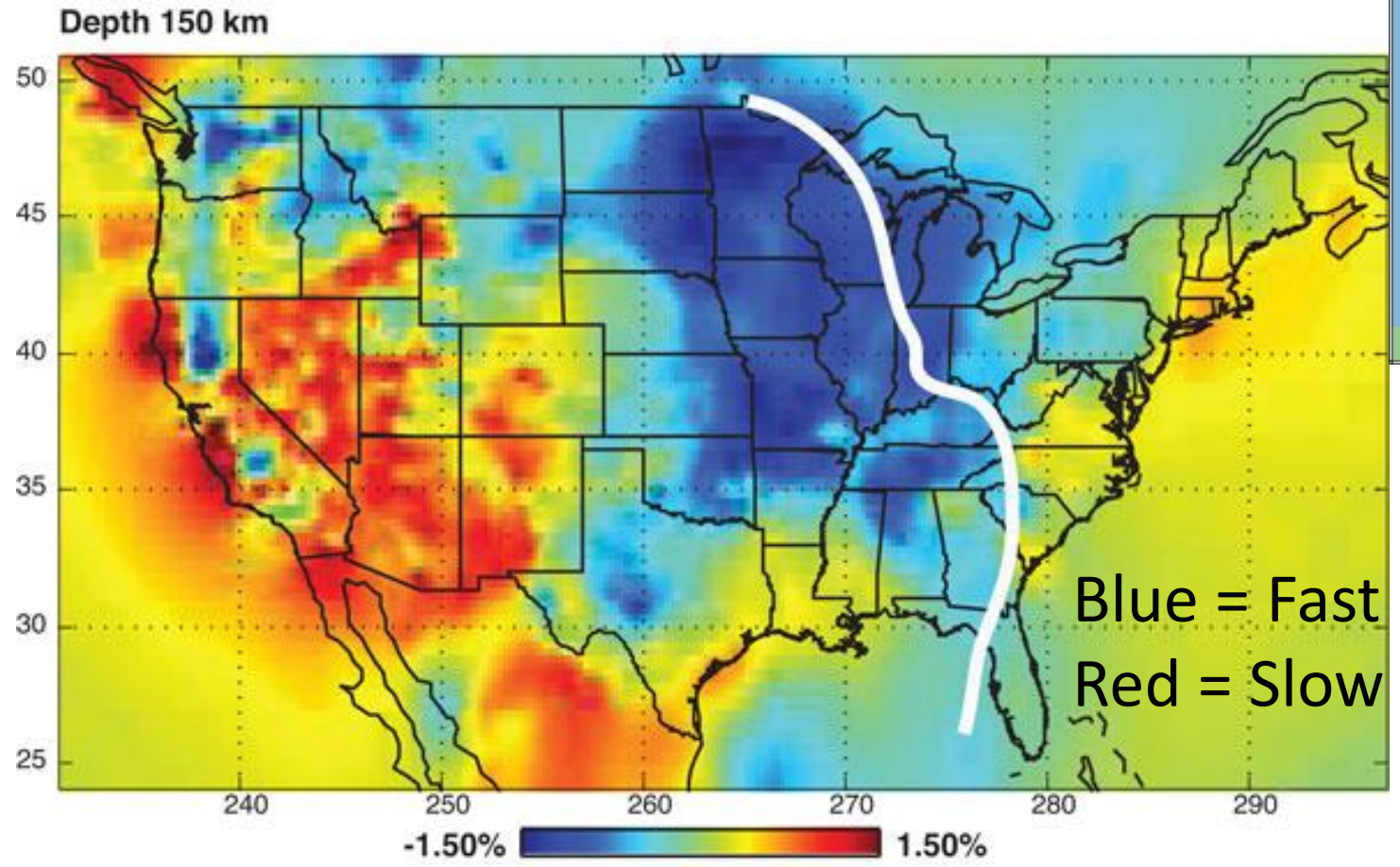
Mesosphere,

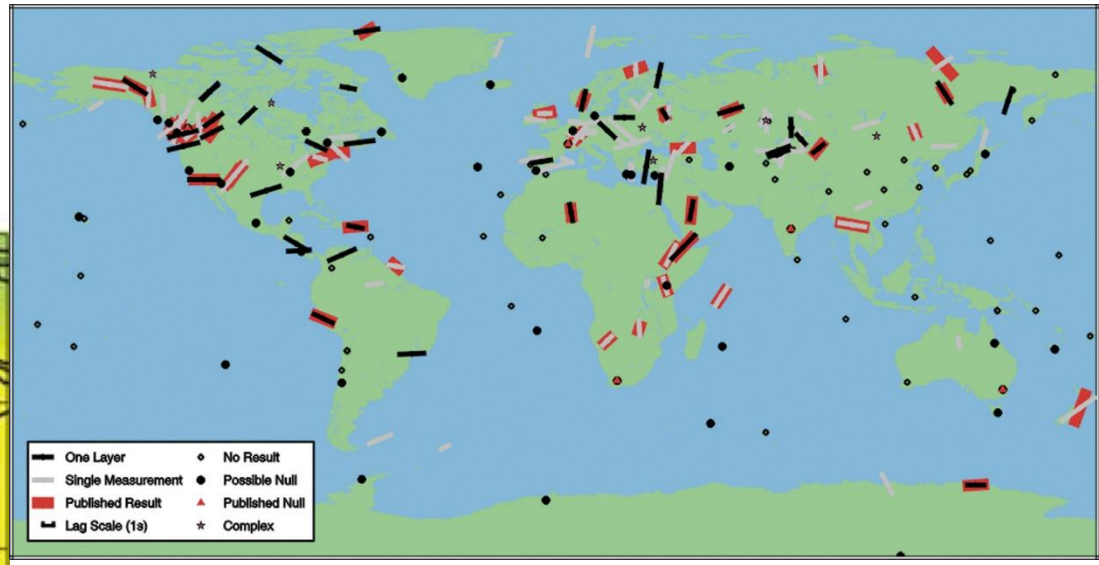
Outer Core,

Inner Core



We use Mantle Tomography and Anisotropy to illuminate *more* details of the mantle!





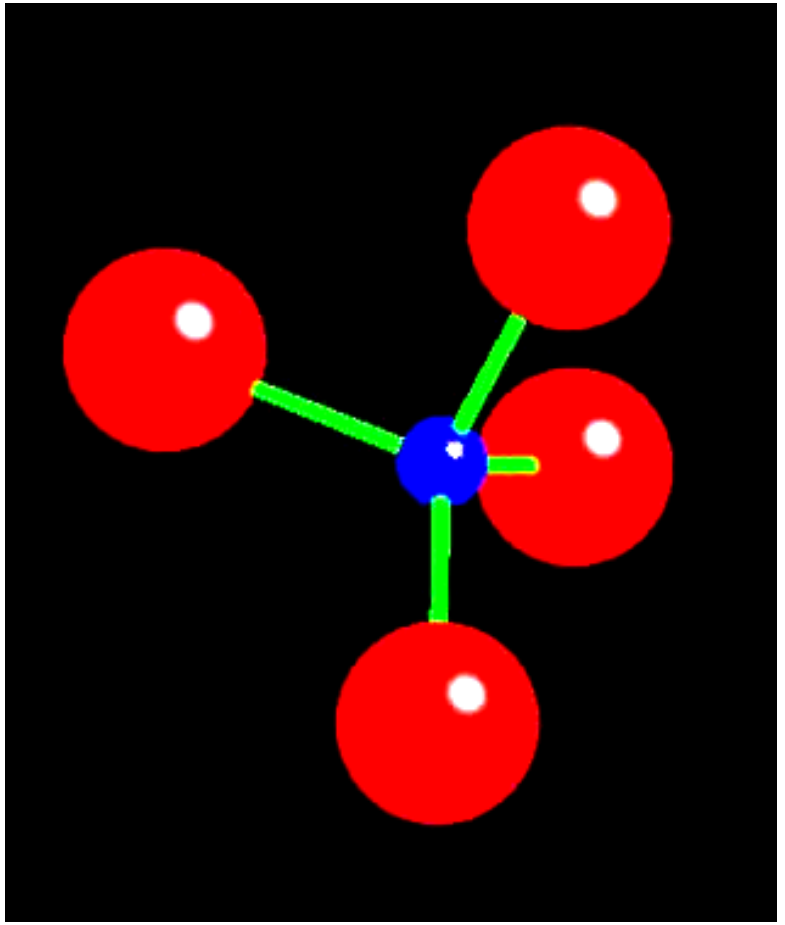
>~ 240 BC, Erastosthenes calculated the diameter of Earth

>~1890 AD, hypothesis of dense core

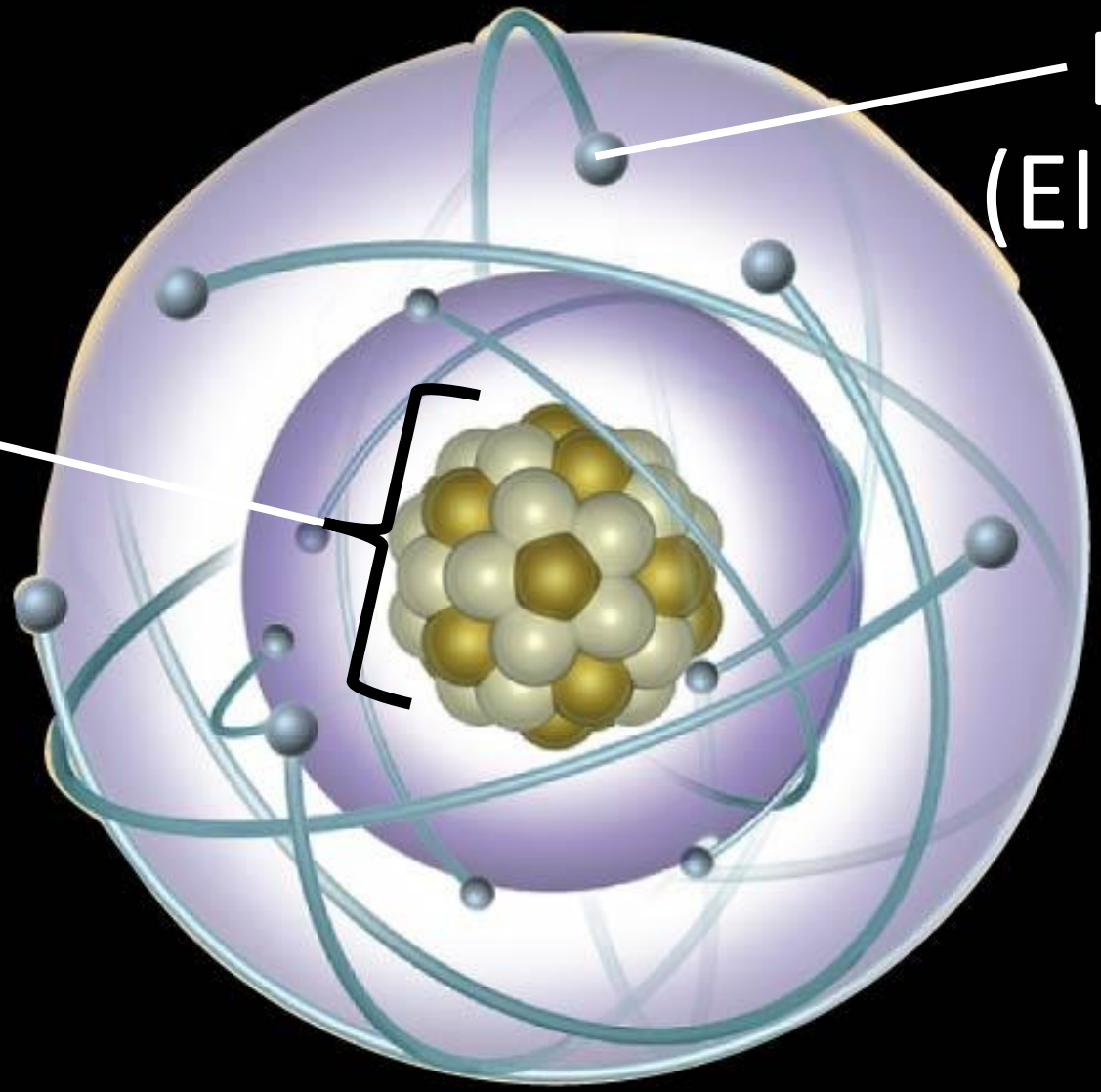
>~1920s, Seismology reveals layers

>Today, we continue to resolve the details of the interior using tomography

Chemistry



Atom



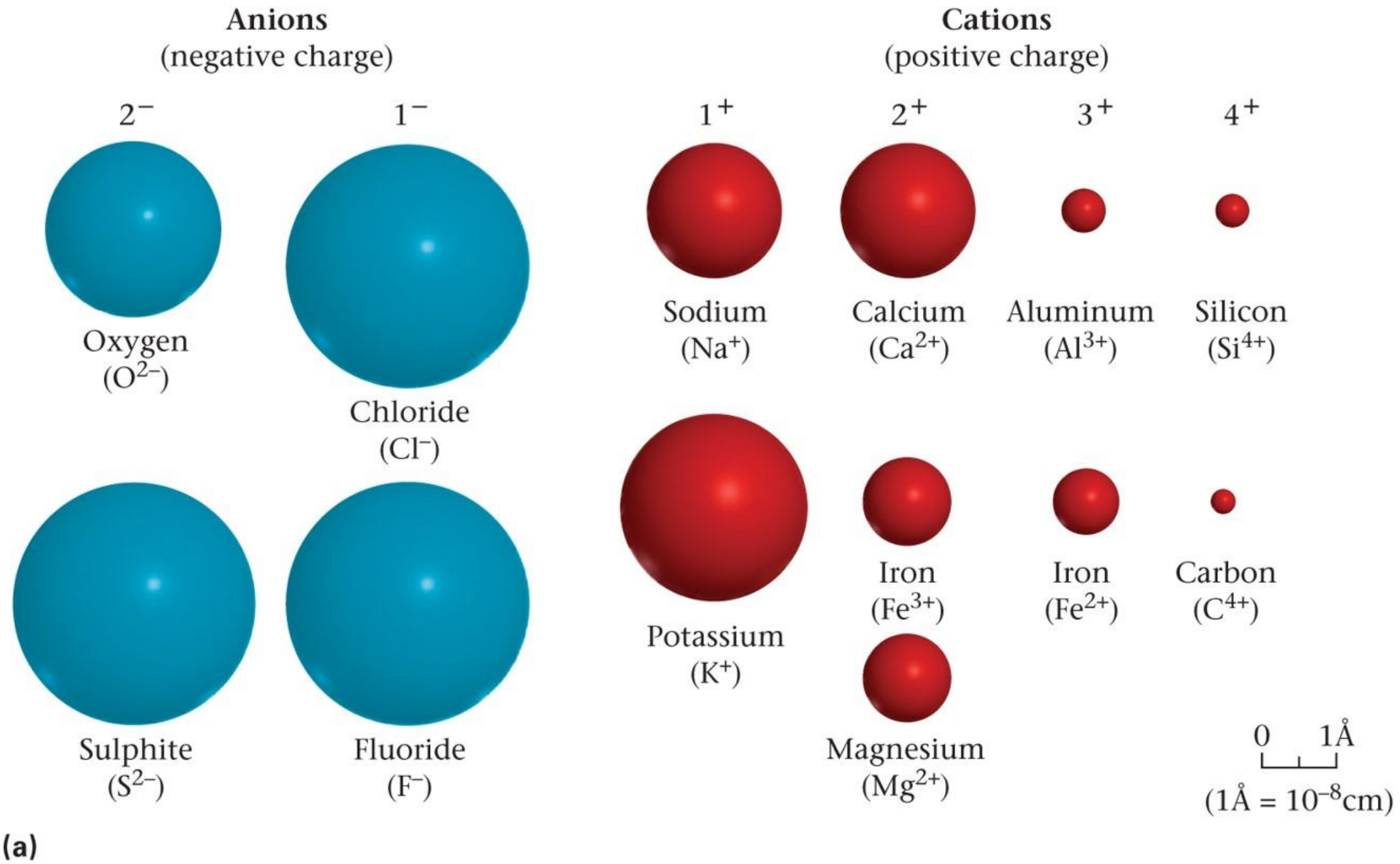
Electron (-)
(Electron Cloud)

Nucleus

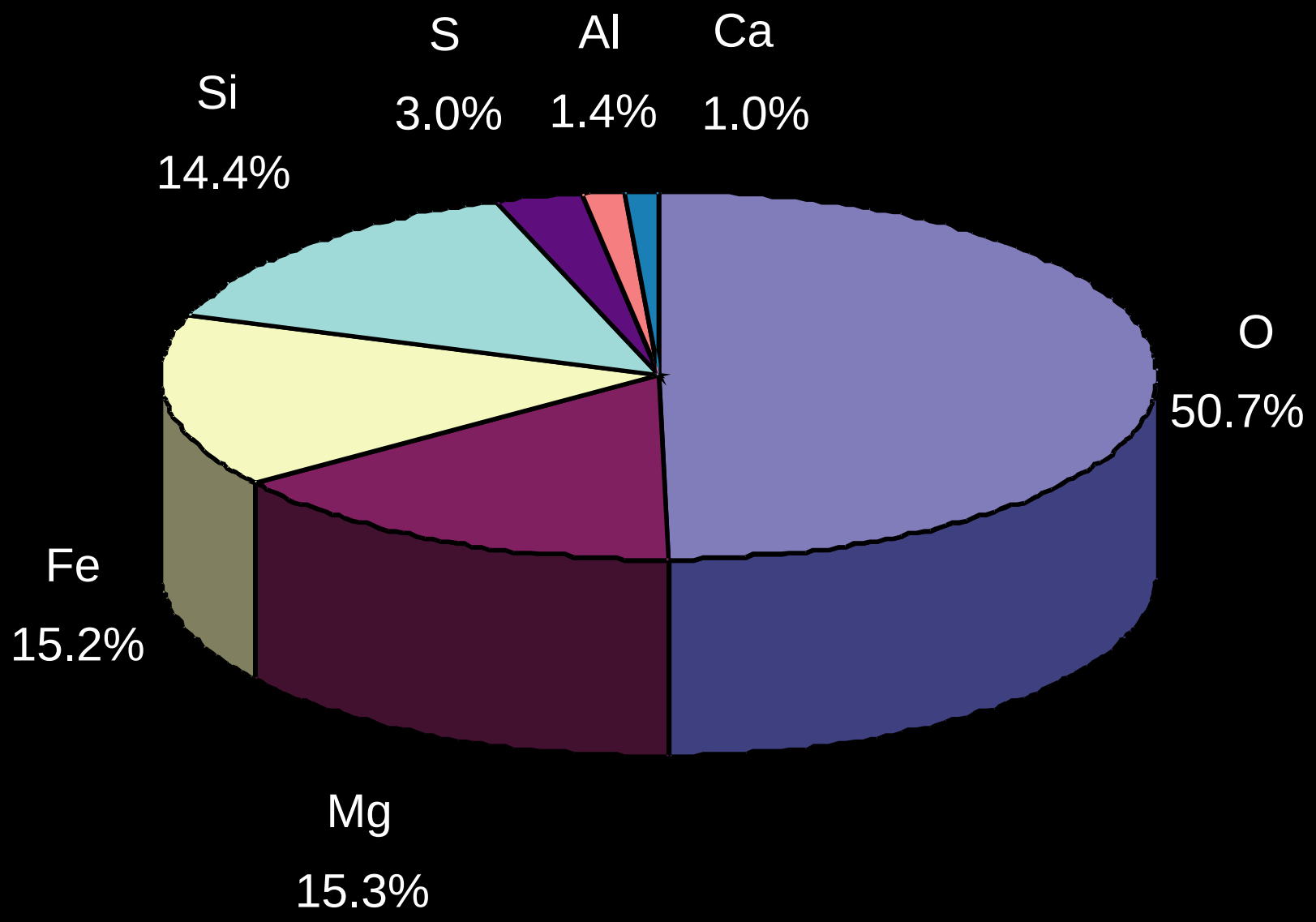
Protons (+)
&
neutrons

Ion:

Charged Element

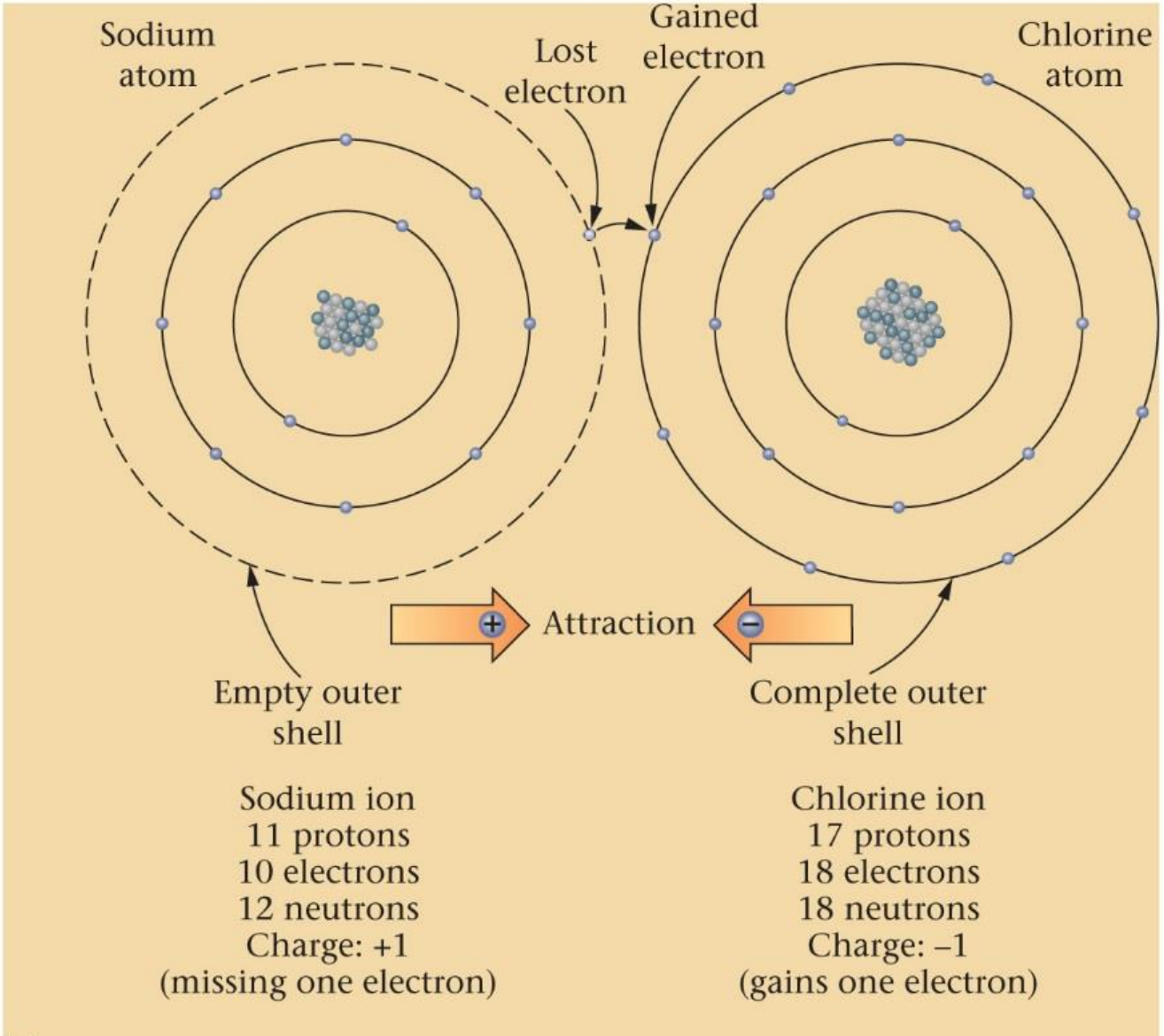


Elemental Composition of Whole Earth

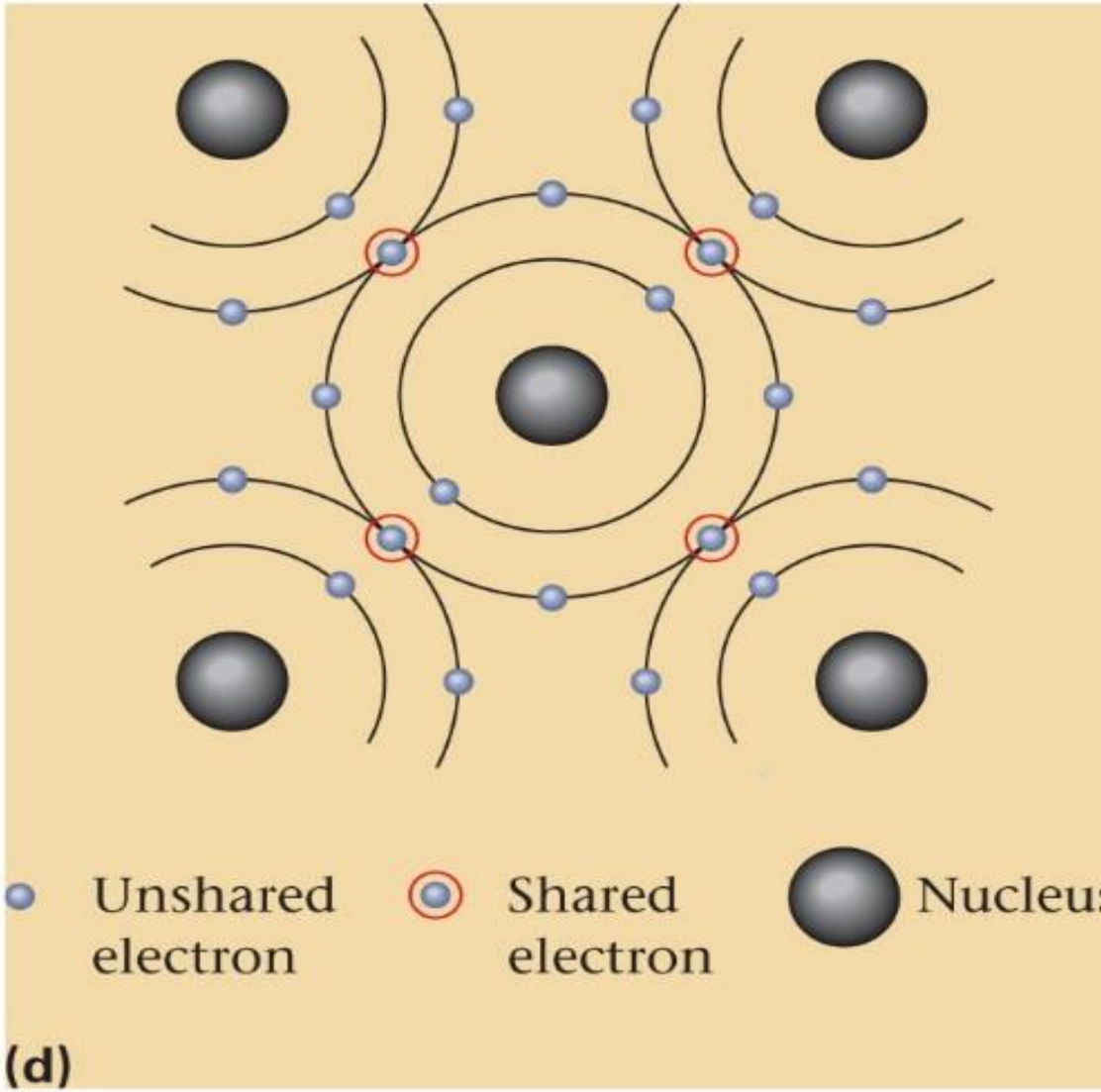


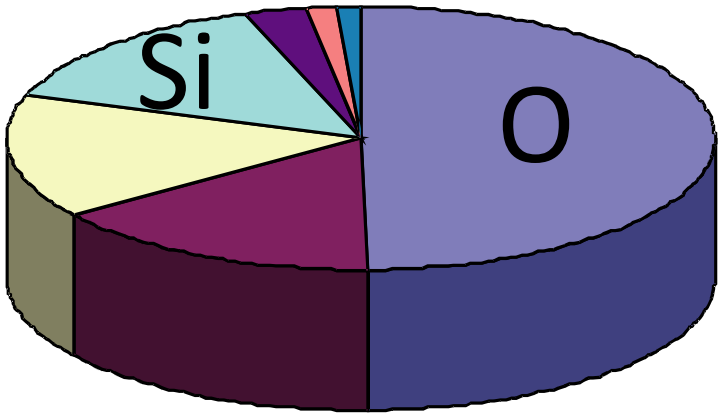
Chemical Bonds

Ionic: Trade e-

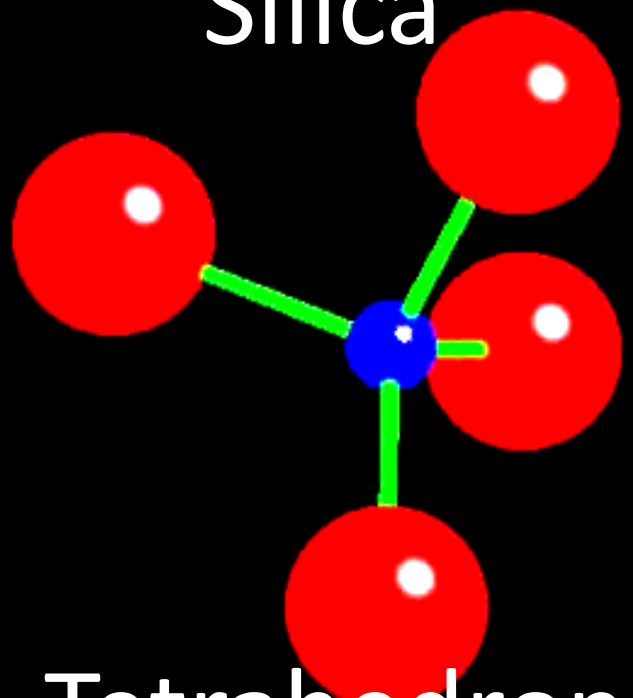


Covalent: Share e-

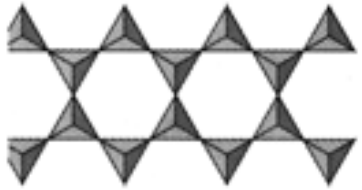
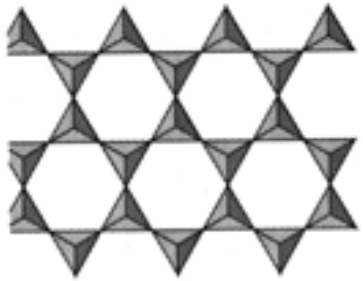




Silica



Tetrahedron

GEOMETRY OF LINKAGE OF SiO_4 TETRAHEDRA		EXAMPLE MINERAL	CHEMICAL COMPOSITION
Isolated tetrahedra: No sharing of oxygens between tetrahedra; individual tetrahedra linked to each other by bonding to cation between them		Olivine	Magnesium-iron silicate
Rings of tetrahedra: Joined by shared oxygens in three-, four-, or six-membered rings		Cordierite	Magnesium-iron-aluminum silicate
Single chains: Each tetrahedron linked to two others by shared oxygens; chains bonded by cations		Pyroxene	Magnesium-iron silicate
Double chains: Two parallel chains joined by shared oxygens between every other pair of tetrahedra; the other pairs of tetrahedra bond to cations that lie between the chains		Amphibole	Calcium-magnesium-iron silicate
Sheets: Each tetrahedron linked to three others by shared oxygens; sheets bonded by cations		Kaolinite Mica (muscovite)	Aluminum silicate Potassium-aluminum silicate
Frameworks: Each tetrahedron shares all its oxygens with other SiO_4 tetrahedra (in quartz) or AlO_4 tetrahedra		Feldspar (orthoclase) Quartz	Potassium-aluminum silicate Silicon dioxide

Elements:

Oxygen & Silicon = Silica [SiO_4^{4-}]

Iron & Magnesium = Mafic

Calcium, Sodium, Potassium } Alkali

Aluminum

Minerals (natural solid, crystalline chemistry):

- Olivine
- Pyroxene
- Amphibole
- Biotite
- Muscovite
- Plagioclase
- Orthoclase
- Quartz

Elements:

Oxygen & Silicon = Silica [SiO_4^{4-}]

Iron & Magnesium = Mafic

Calcium
Sodium
Potassium
} Alkali
Aluminum

Minerals (natural solid, crystalline chemistry):

Olivine
Pyroxene **[Mafics]**
Amphibole
Biotite

Muscovite [Aluminosilicates]

Plagioclase
Orthoclase
} Feldspars

Quartz [Pure Silica]

Rocks

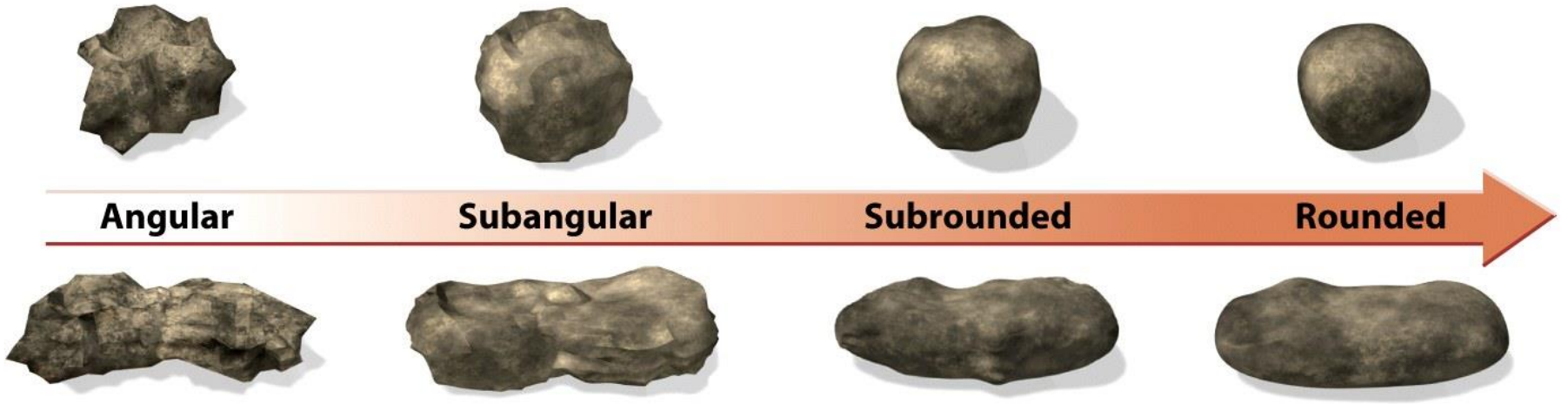
Igneous:

Rock made of crystals

Solidified from Melt

Sedimentary:

Rock made of Smaller rocks



Product of Erosion and deposition

Name	Size Range
Boulders	> 256 mm
Cobbles	64 – 256 mm
Pebbles	2 – 64 mm
Sand	1/16 – 2 mm
Silt	1/256 – 1/16 mm
Mud	< 1/256 mm

Sedimentary:

Rock made of Smaller rocks

conglomerates

sandstones

shales

Product of Erosion and deposition

Non-silicate class of Sedimentary Rocks! Limestones! Made of Calcium Carbonate

Name	Size Range
Boulders	> 256 mm
Cobbles	64 – 256 mm
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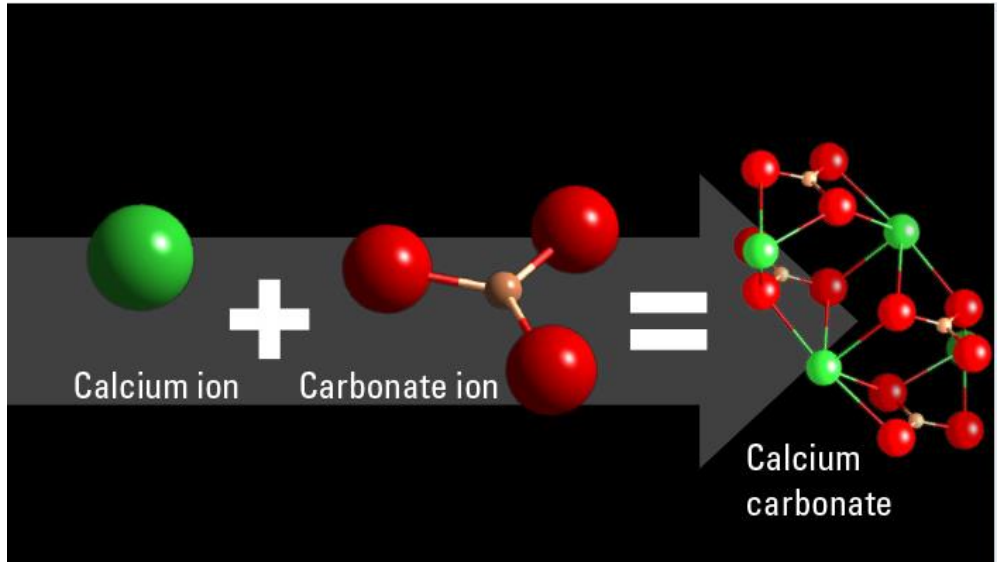
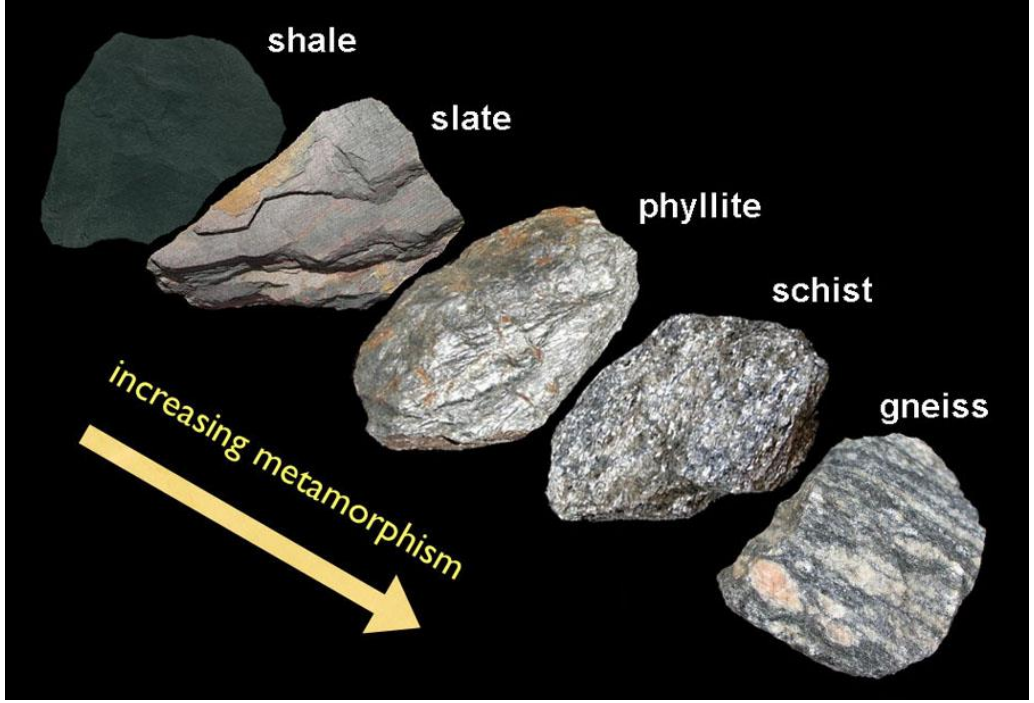
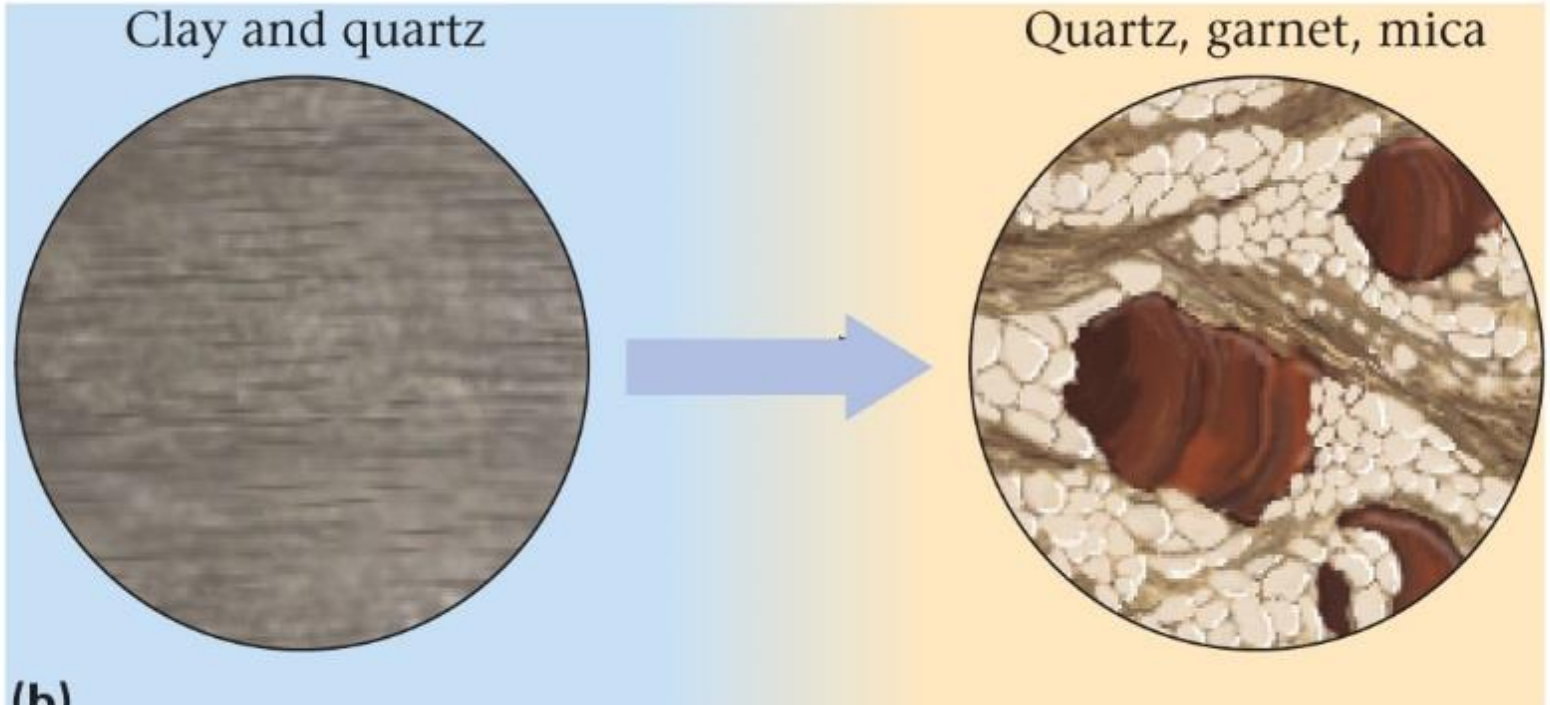


Metamorphic:

Rock with a ‘Fabric’, or Orientation of minerals

Product heat And pressure





Rocks

Igneous	Sedimentary	Metamorphic
Peridotite	Conglomerate	Slate
Basalt (Gabbro)	Sandstone	Schist
Rhyolite (Granite)	Shale	Gneiss
	Limestone	Marble

Recap

Earth is layered, by Composition and mechanical properties

Chemistry is matter; elements are the building blocks or minerals, which are the building blocks of…

Rocks. The Earth is made of these and can be classified into three types which form by different earth processes

Friday

Q/A

Discussion of *Earth in Human Hands* excerpt

Week 2
Formation of Solar System: Violent Origins
(week 3 on syllabus)