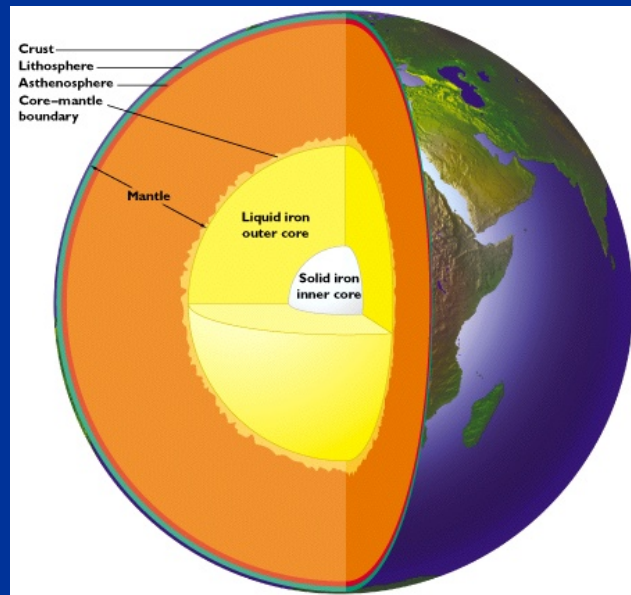


Exploring the Earth's Interior



How do we know about the Earth's Interior?

- By studying Meteorites
- Direct observation (rocks originating from depth)
- Experiments at high pressure
- By studying earthquake waves (Seismology)



Meteorites have struck the Earth in the past.

Many are probably pieces of proto-planets similar in composition to Earth.

Meteorites Accumulate Daily



Meteorites



Stony meteorites are rich in
olivine and pyroxene

Similar to Earth's lithosphere

Meteorites



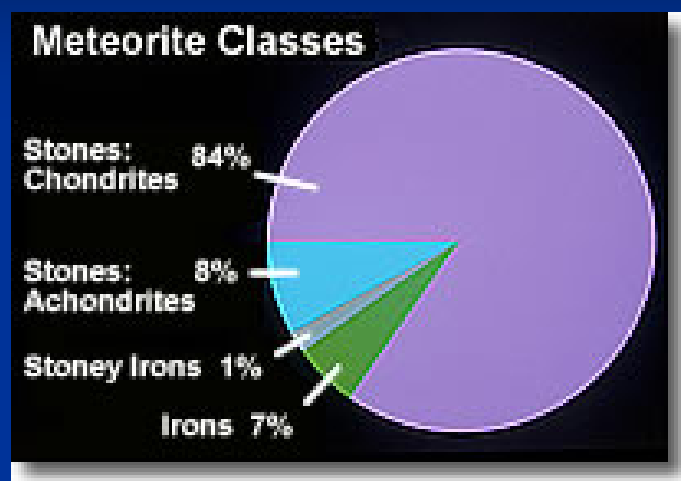
Iron meteorites are
made of iron and
nickel

Earth's interior
(core) is similar

Types of Meteorites - I

- Stones
 - Primarily silicates (like Earth's crust and mantle)
 - >90% of all meteorites
- Irons
 - Iron-nickel alloys
- Stony irons
 - Combination of stony and iron meteorites

Types of Meteorites - I



Types of Meteorites - II

- Falls
 - Meteorites observed falling to the ground
 - Primarily stones (suggests they are more common)
- Finds
 - Meteorites discovered on the ground
 - Primarily irons (collected because they are unusual looking)

How do we know about the Earth's Interior?

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Large Volcanic Eruptions



- Voluminous volcanic eruptions
- Sample significant part of mantle
- Can infer something about mantle composition

Kimberlites

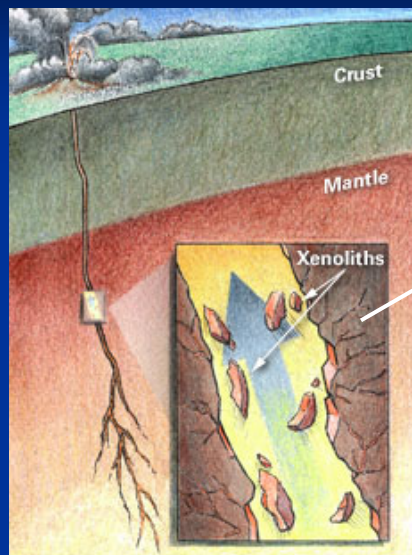


- Rapidly injected rock
- Volatile-rich
- Often contain diamonds
- Known to form at high pressure - deep in mantle (>400 km)
- Hosted by mantle rock

Kimberlites



Kimberlites Sample Mantle

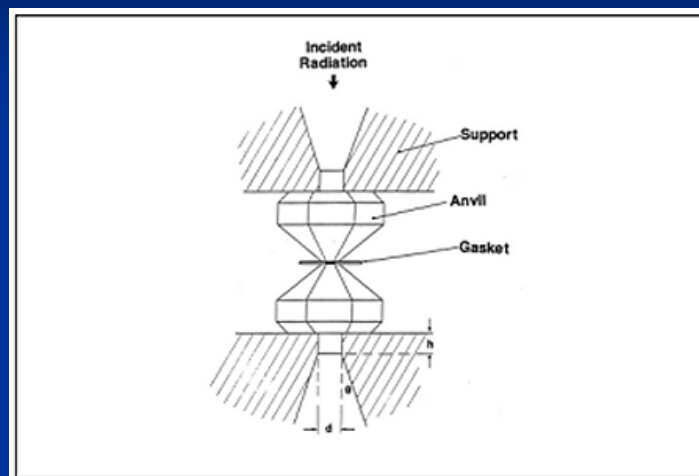


Peridotite

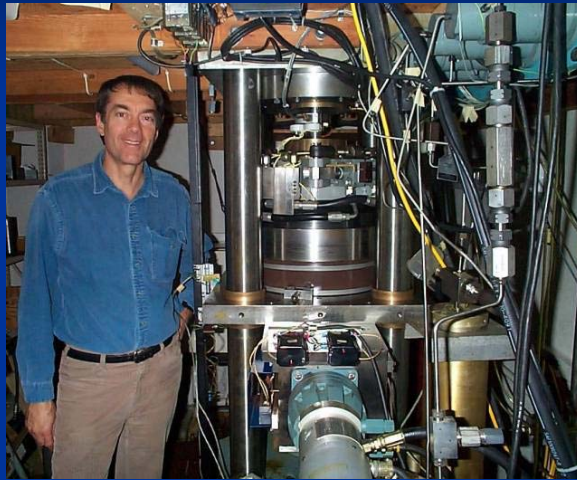
How do we know about the Earth's Interior?

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Diamond-anvil cell



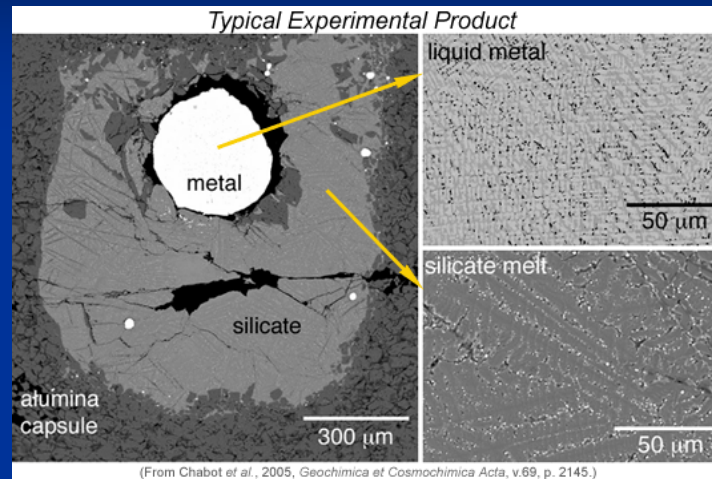
Diamond-anvil cell



Multi-anvil Press



Multi-anvil Press



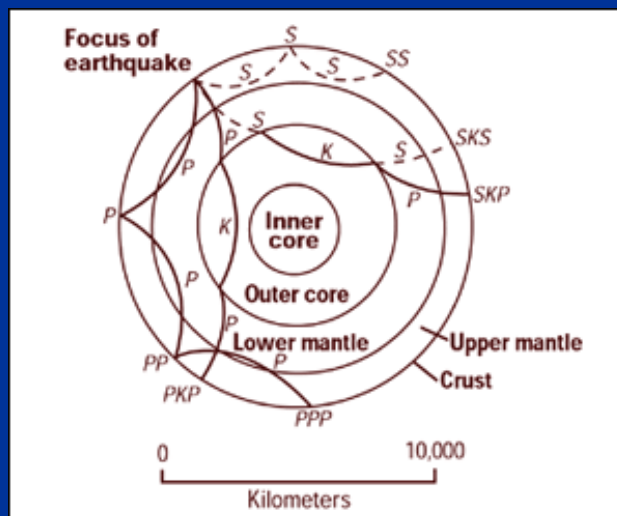
Seismology

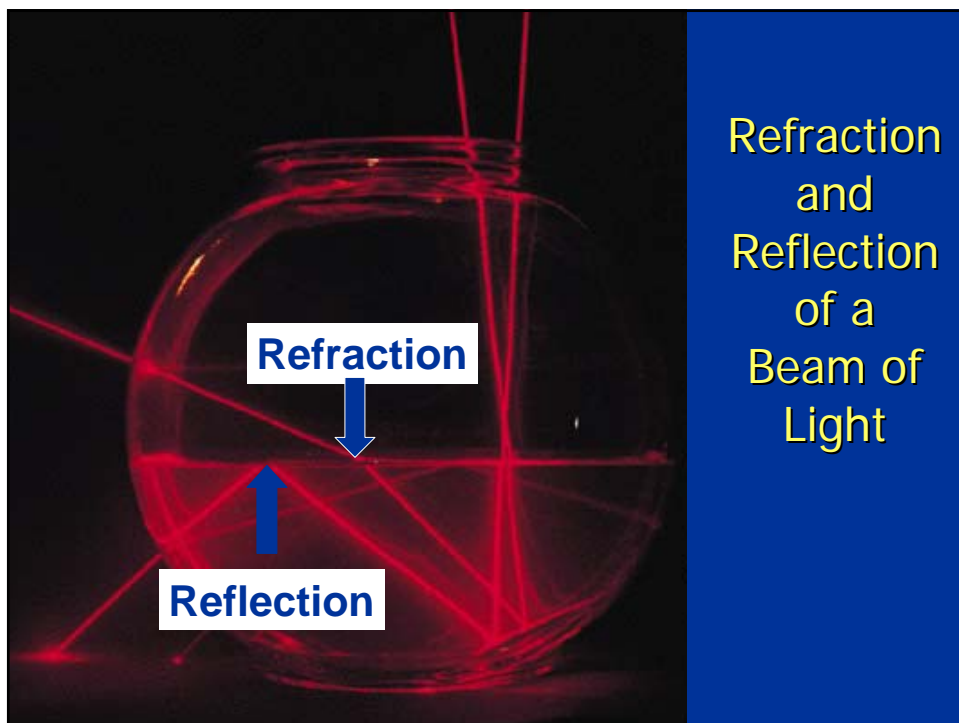
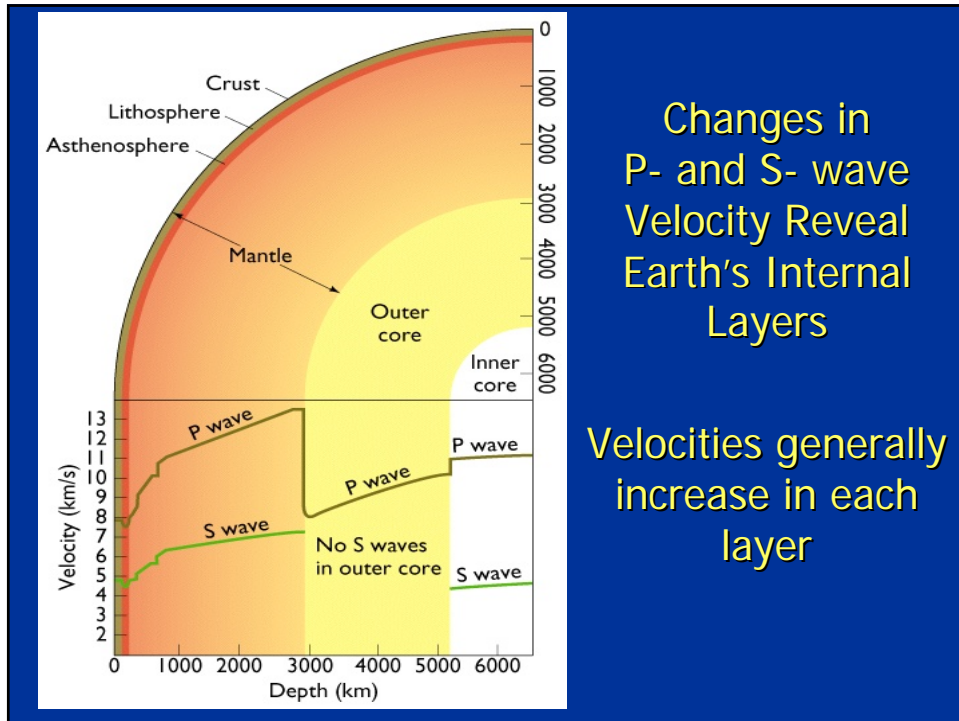
- Study of the propagation of mechanical energy released by earthquakes.
- When energy is released, waves of motion (like the effect of a pebble tossed into a pond) are set up in the Earth.

Structure of the Earth

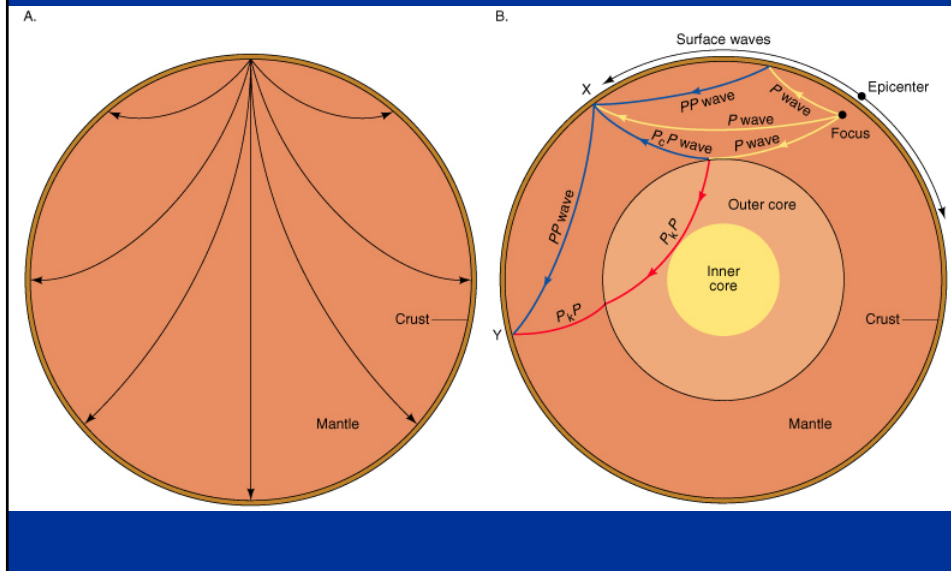
- Seismic velocity (how fast earthquake waves travel through rocks) depends on the composition of material and pressure.
- We can use the behavior of seismic waves to tell us about the interior of the Earth.

Types of Seismic Waves

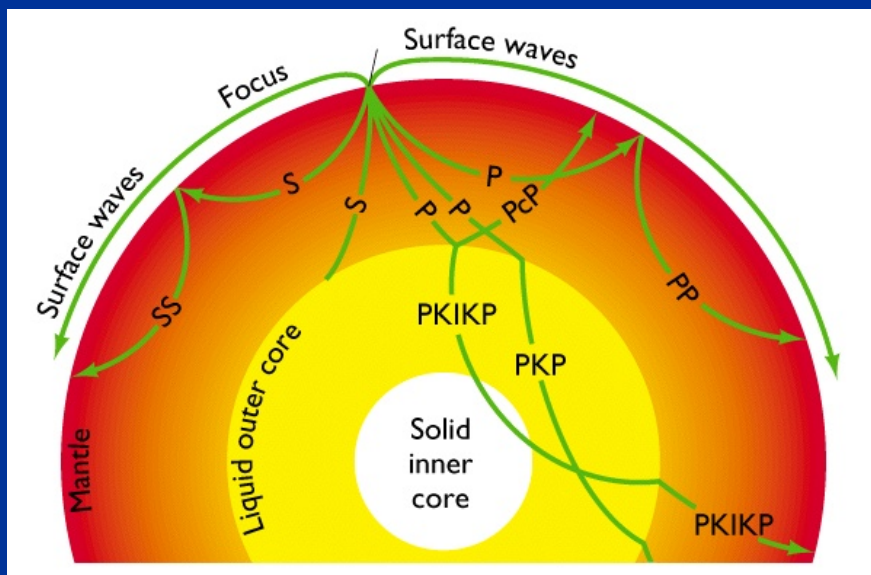




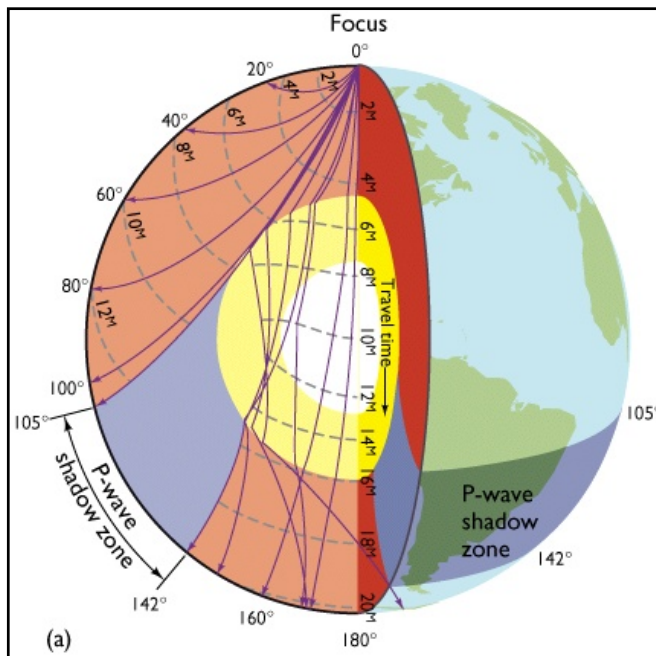
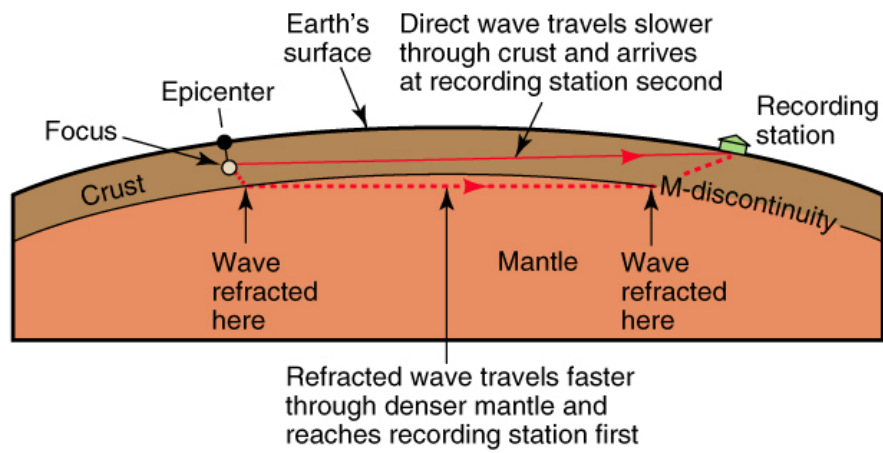
Refraction and reflection of seismic body waves



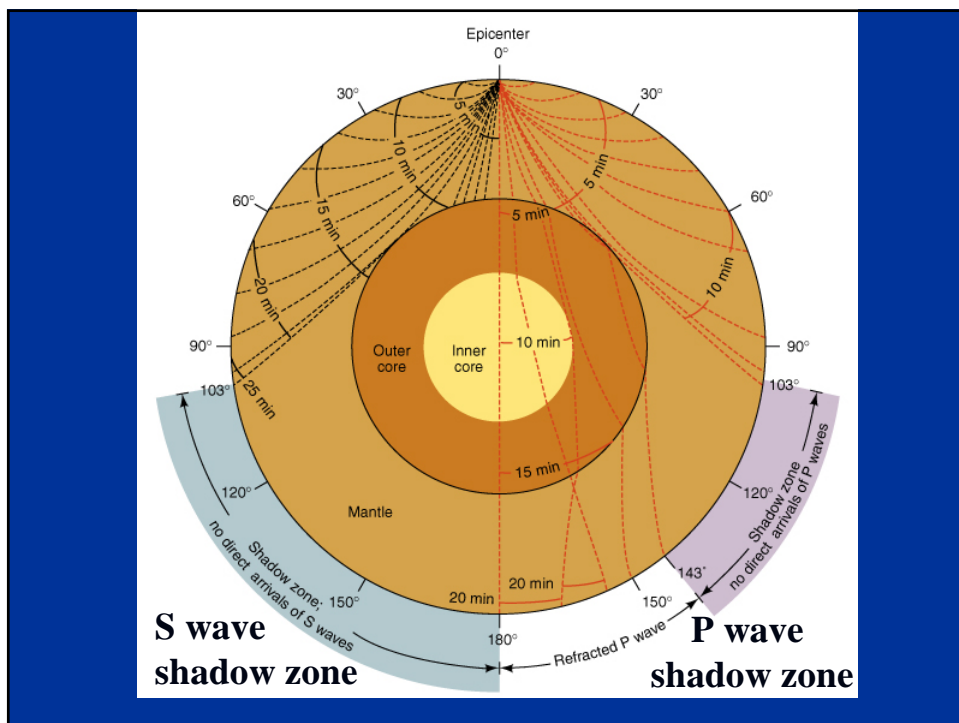
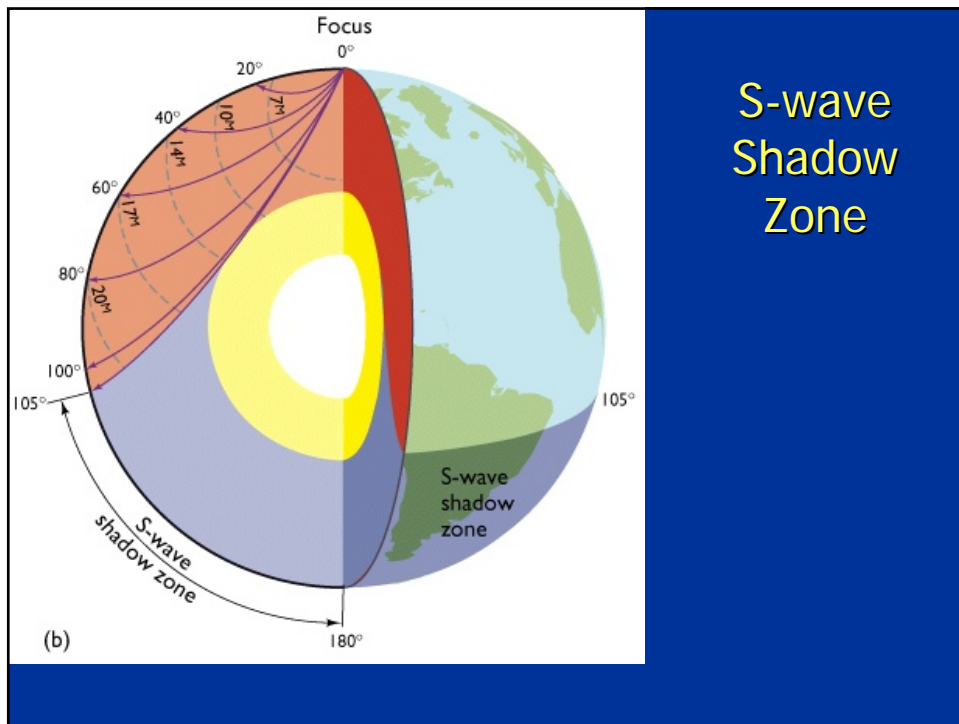
P-and S-wave Pathways Through Earth



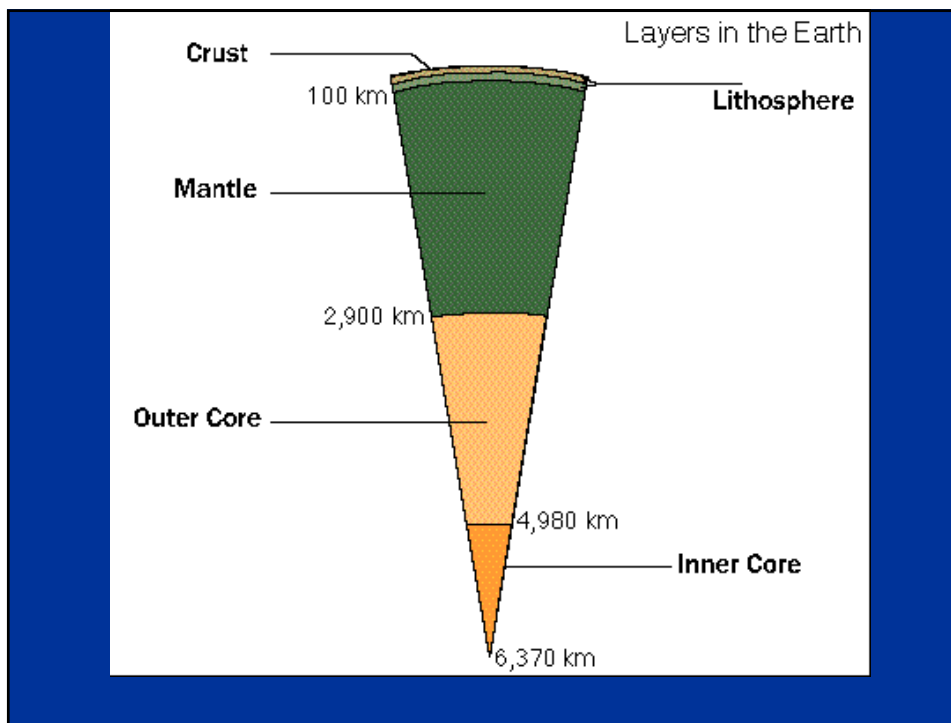
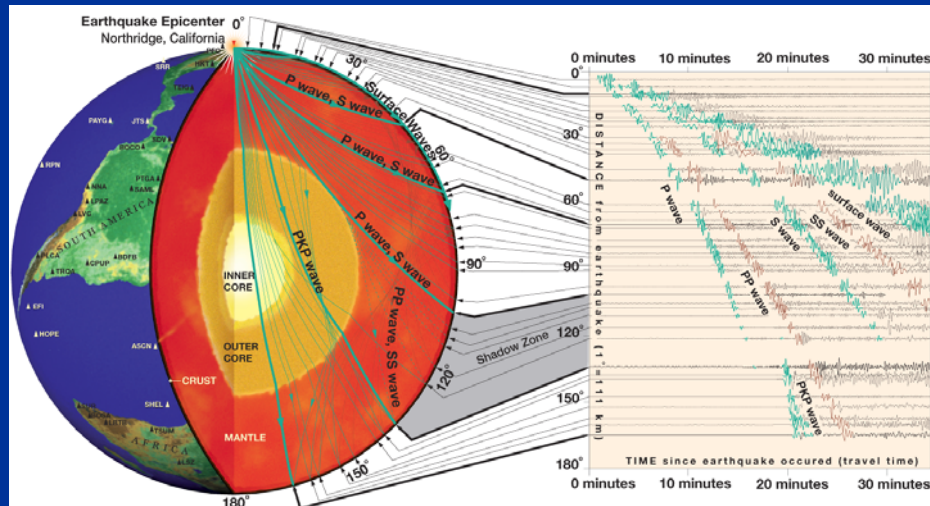
Travel paths for shallow seismic waves



P-wave
Shadow
Zone



Seismology and Earth structure



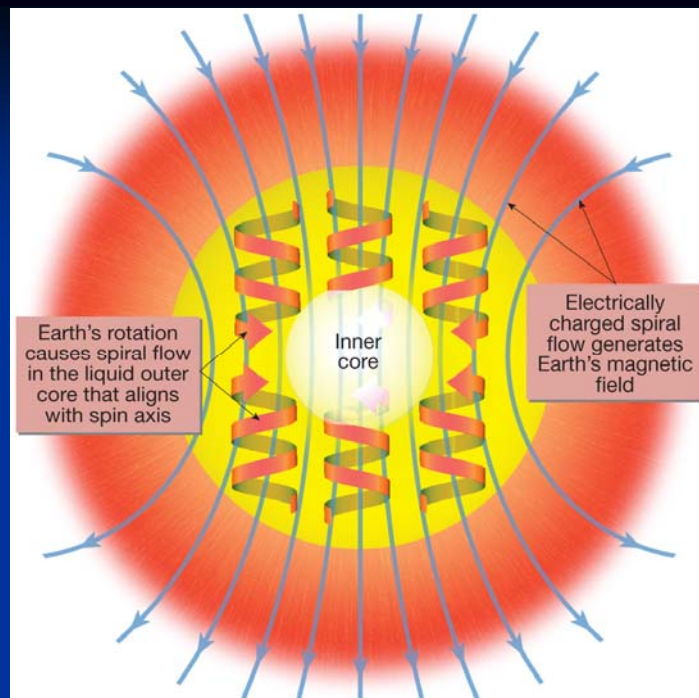
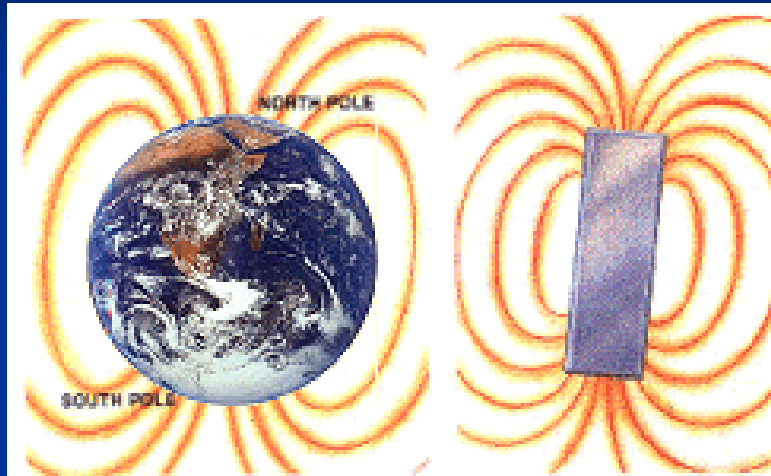
Layers of the Earth

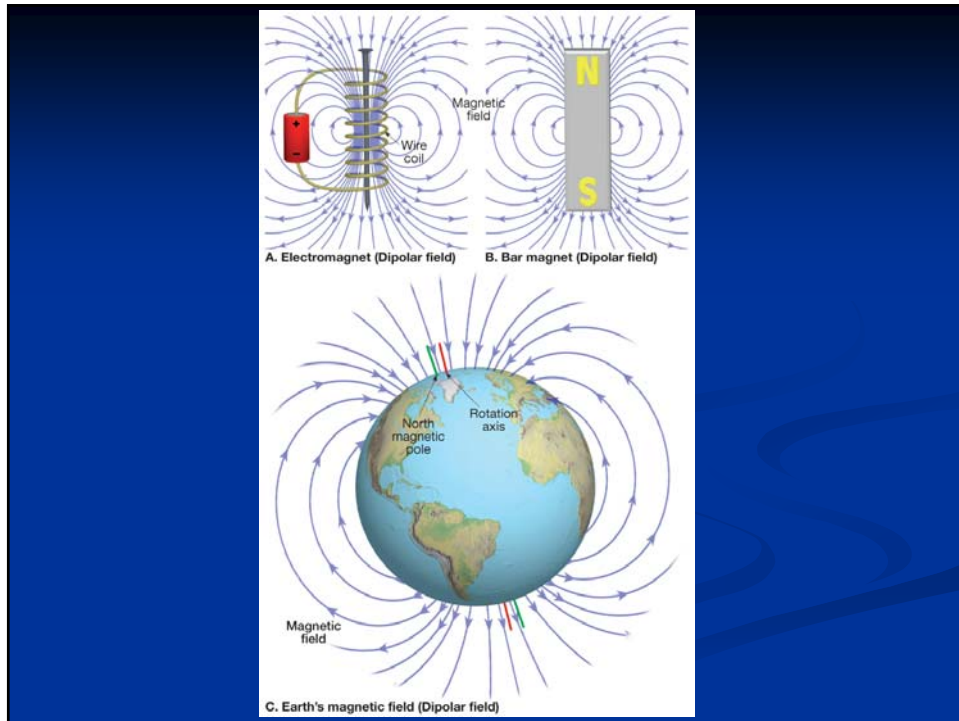
Data on the Earth's Interior				
	Thickness (km)	Density (g/cm ³)		Types of rock found
		Top	Bottom	
Crust	30	2.2 —	— 2.9	Silicic rocks. Andesite, basalt at base.
Upper mantle	720	3.4 —	— 4.4	Peridotite, eclogite, olivine, spinel, garnet, pyroxene. Perovskite, oxides.
Lower mantle	2,171	4.4 —	— 5.6	Magnesium and silicon oxides.
Outer core	2,259	9.9 —	— 12.2	Iron+oxygen, sulfur, nickel alloy.
Inner core	1,221	12.8 —	— 13.1	Iron+oxygen, sulfur, nickel alloy.
Total thickness	6,401			

Earth's CORE

- *Outer Core* - Liquid Fe, ~2200 km thick,
No S-waves transmitted -> S- & P-wave
Shadow Zones
- *Inner Core* - solid Fe (some Ni, Co, S, C),
~2500 km thick
- *How do we know?* Meteorites,
Seismology, Magnetic field

Earth's Geodynamo



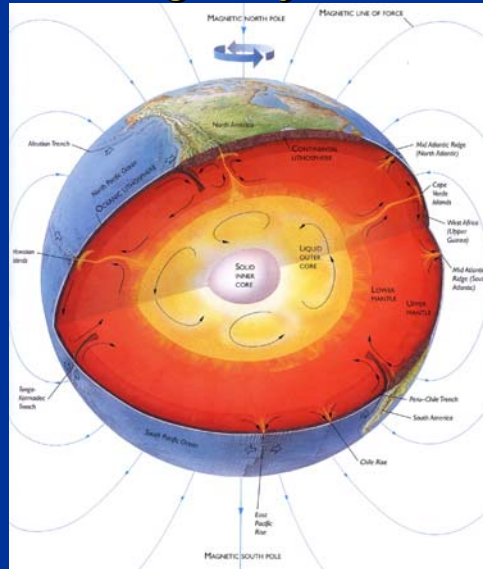


Origin of Earth's magnetic field: the geodynamo

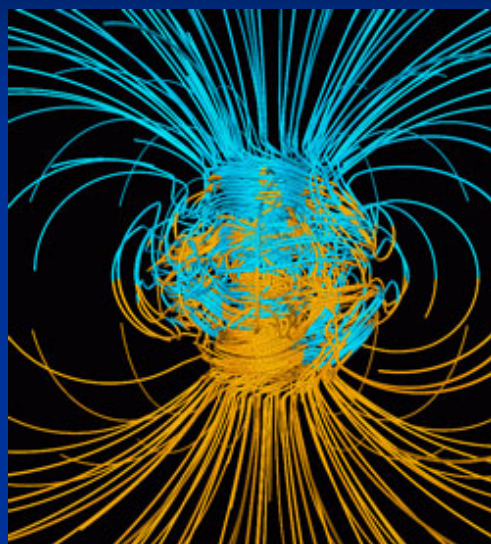


- The basic idea: an electric motor is a dynamo
- Motion of the liquid outer core -- a conductor -- in a magnetic field generates current
- The current generates a stronger magnetic field

Origin of Earth's magnetic field: the geodynamo



Modeled Geodynamo

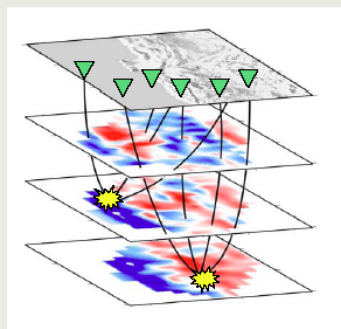


Mantle Tomography

- Uses numerous seismic data
- Uses small changes in speed of seismic waves
- Faster wave motion may correspond to denser or colder regions
- Slower wave motion may correspond to buoyant or warmer regions

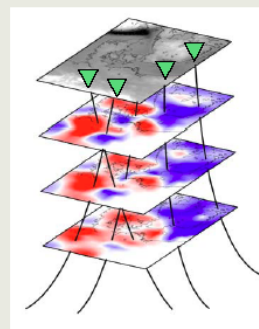
Basics of Tomography

Local Earthquake Tomography



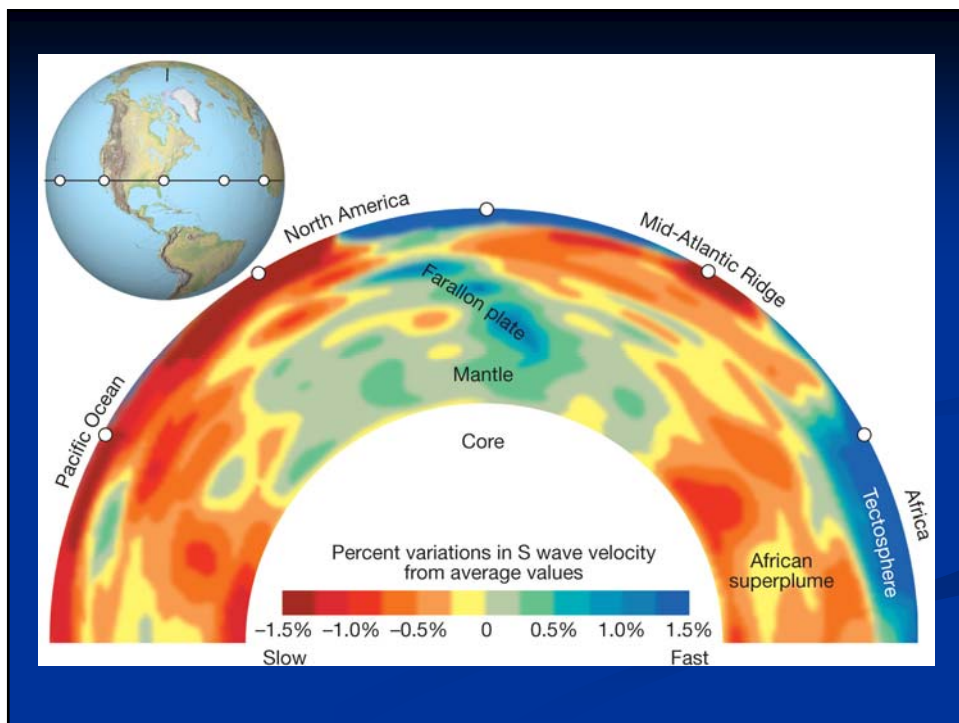
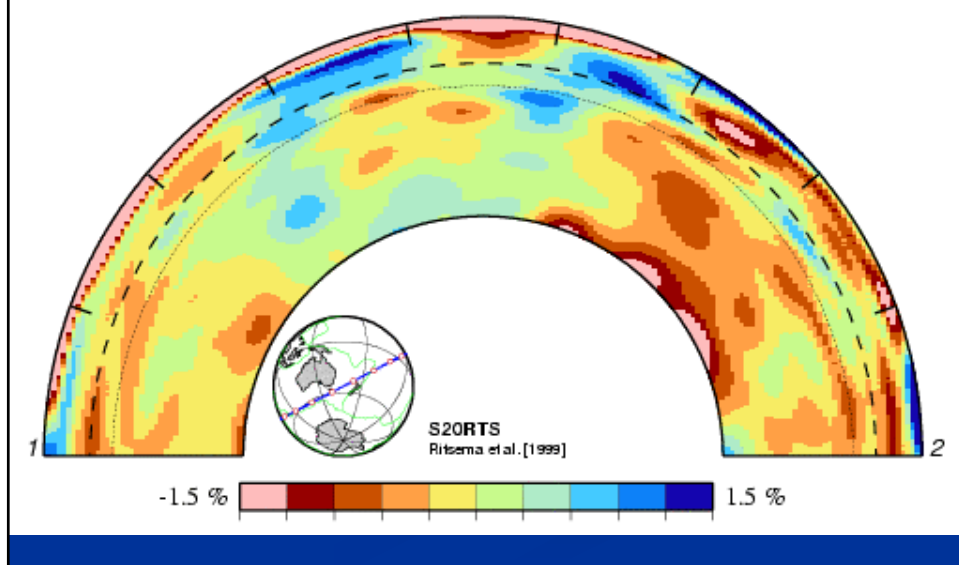
source and receiver with
in the study volume
crustal studies

Teleseismic Tomography



sources are outside study
volume
mantle studies

Tomography of the Mantle



Tomography Beneath Active Volcanoes

