GLY4155

Geology of Florida (3 Credits)

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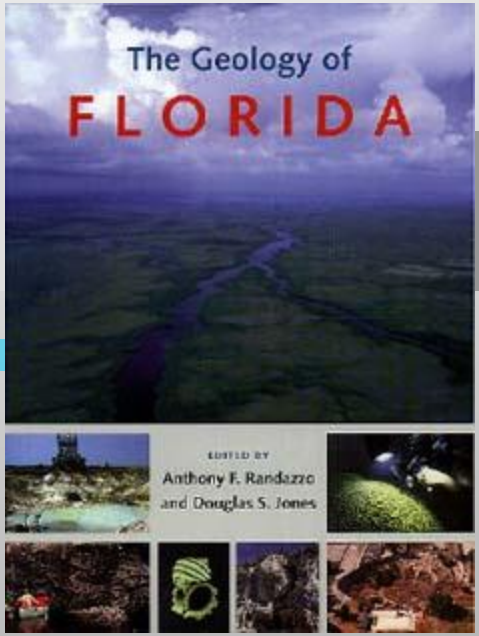


Textbook: *The Geology of Florida* (Editors Randazzo and Jones).

Grading Policy: Grades will be determined on the basis of 3 exams, Projects (in-class and out of class) and class participation. Exams are 20% each (3 x 20%=60%); Projects are 30% and class participation is 10%.

Course Outline

Introductory Lectures: Review/Introduction of Physical and Historical Geology
Geomorphology and Geography of Florida
Florida Basement: Our Origins in Africa
Sedimentary Platforms of Florida
Miocene Holocene of Florida
Geology of Florida Coast/Coastal Processes
Evolution of the Florida Platform
Hydrogeology of Florida
Mineral Industry of Florida

Introductory Lectures: Physical Geology

Formation of the Earth: Interior Composition

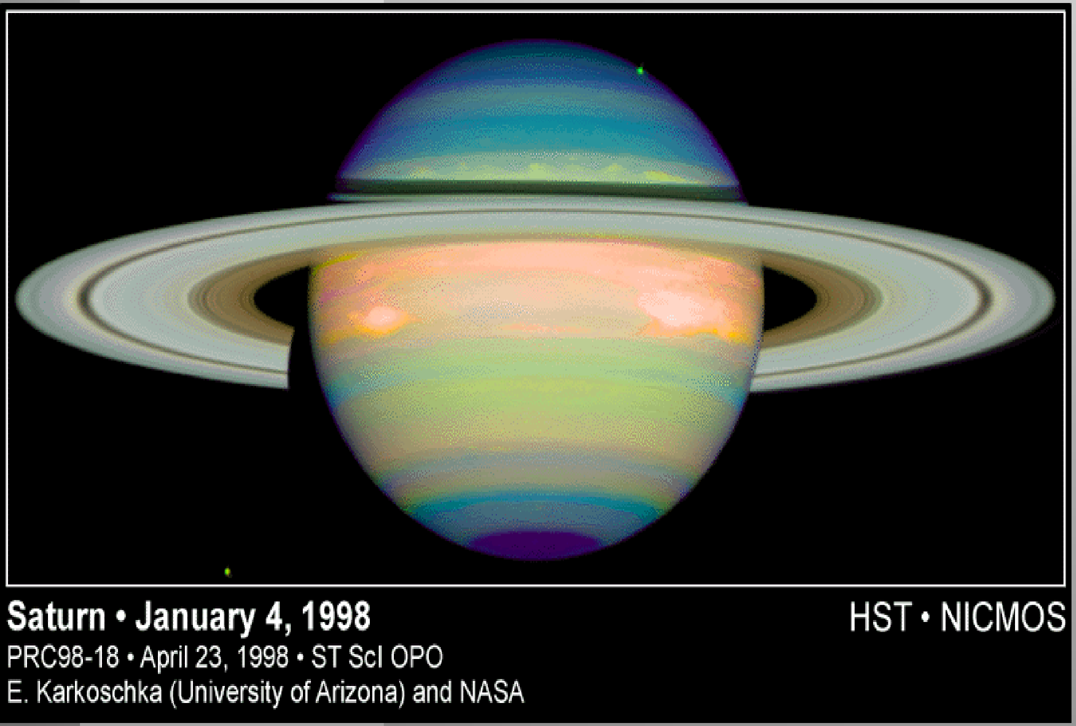
Minerals and Rocks: Building Blocks of the Planet

Age of the Earth

A Brief History of Time

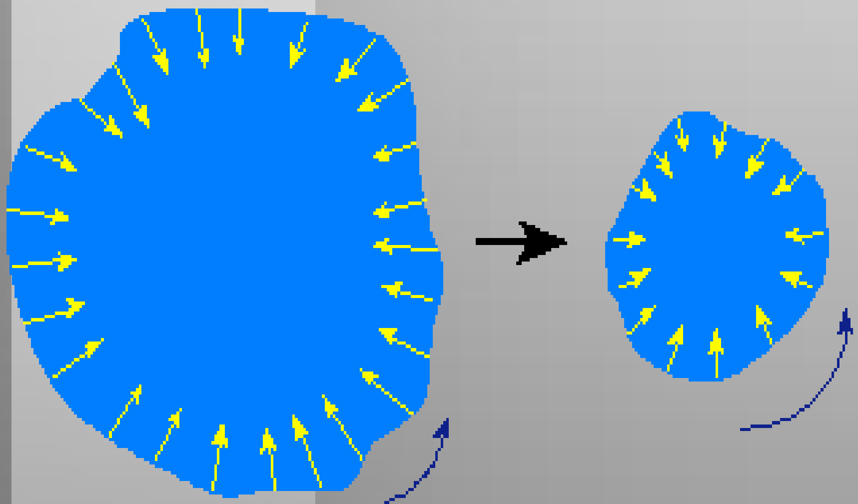
A Brief History of Life on Earth

Formation of Our Solar System



- How old is our solar system?
- Are we the product of an earlier solar system?
- How do we know this?

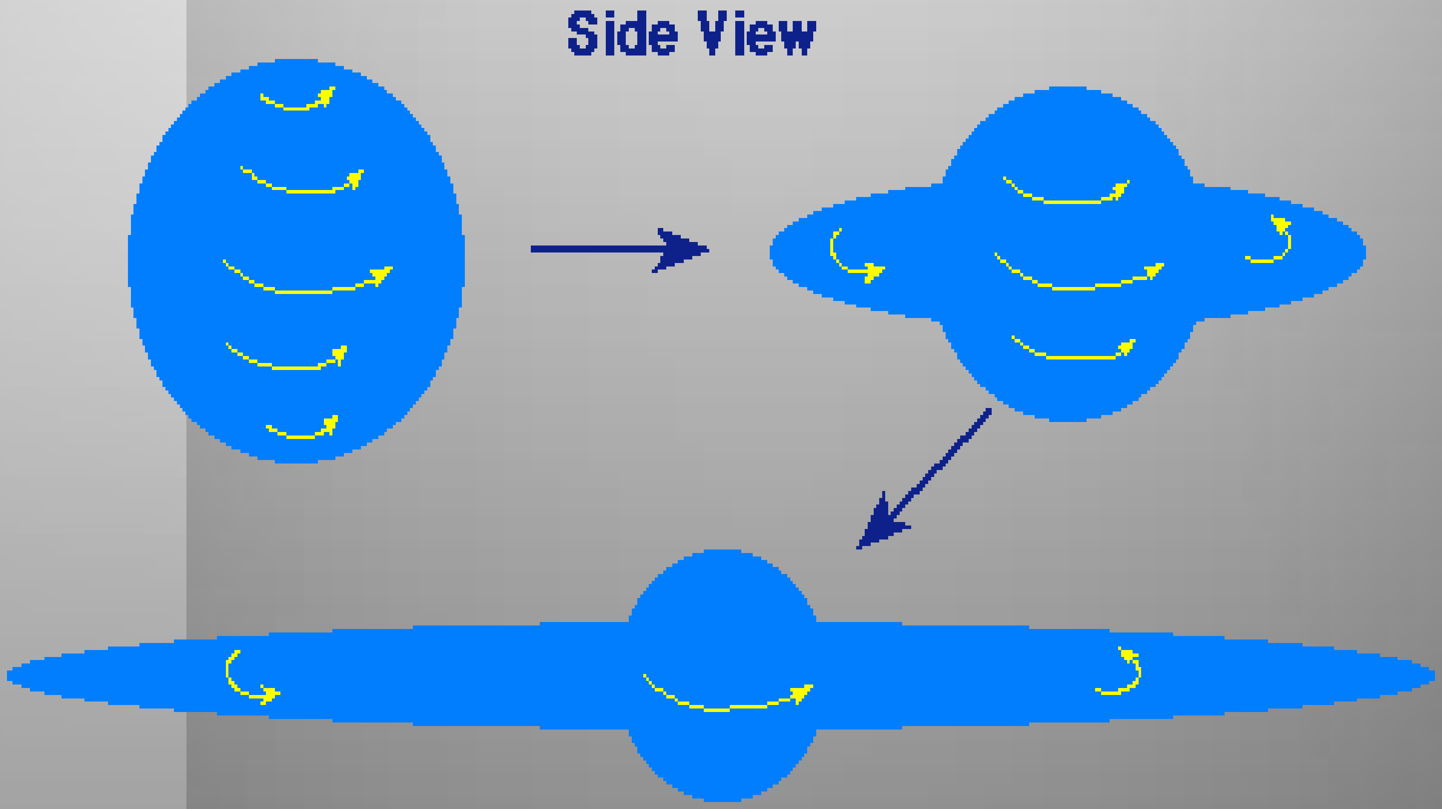
Nebular Condensation Hypothesis



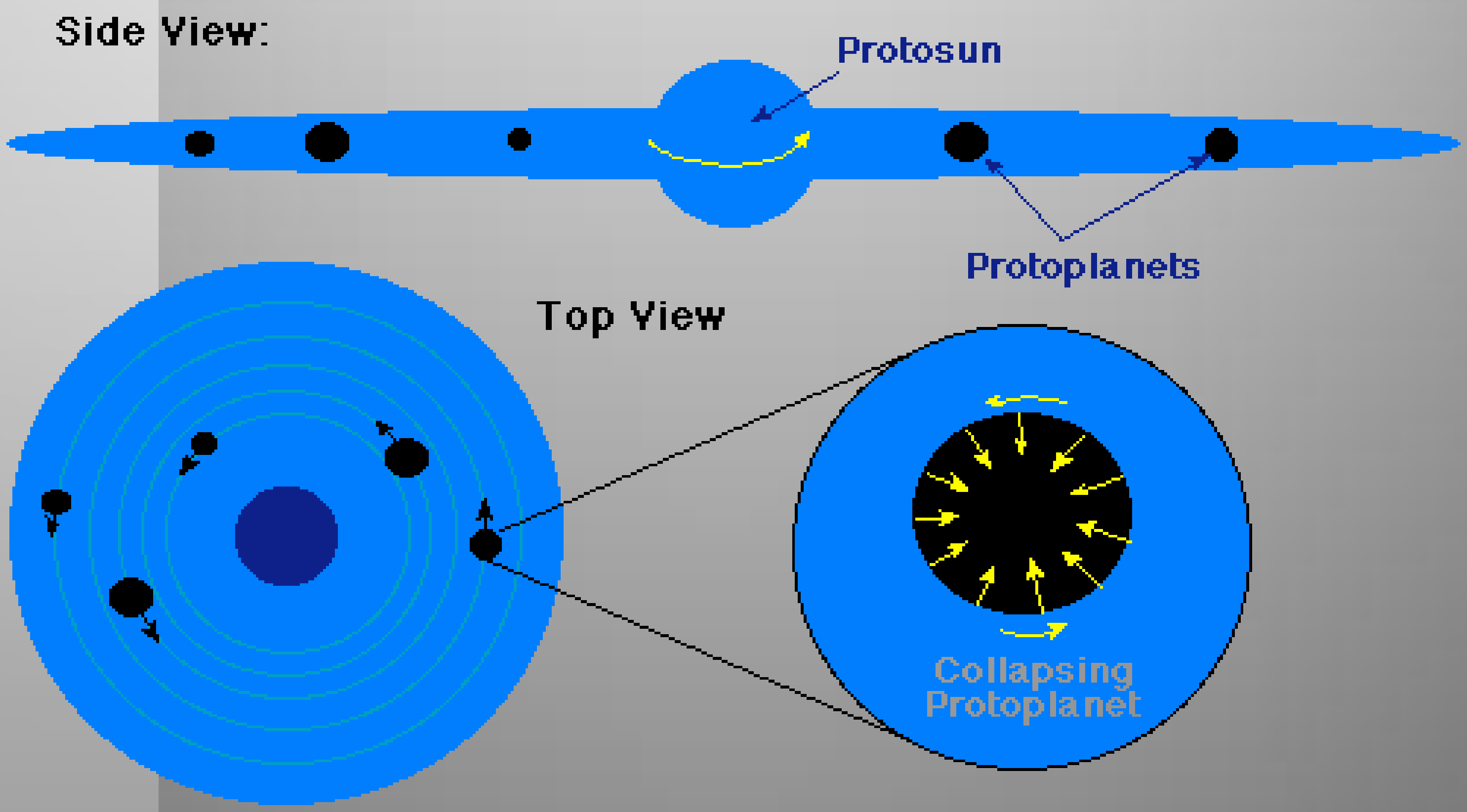
The cloud spins more rapidly as it collapses because of conservation of angular momentum

- Dense agglomeration of matter begins to contract.
- Cloud begins to rotate and flatten like a pancake.
- Rings of high density material form
- Rings condense into planets.
- 99% of the mass should locate in the center
- 99% of the angular momentum should reside in the planets

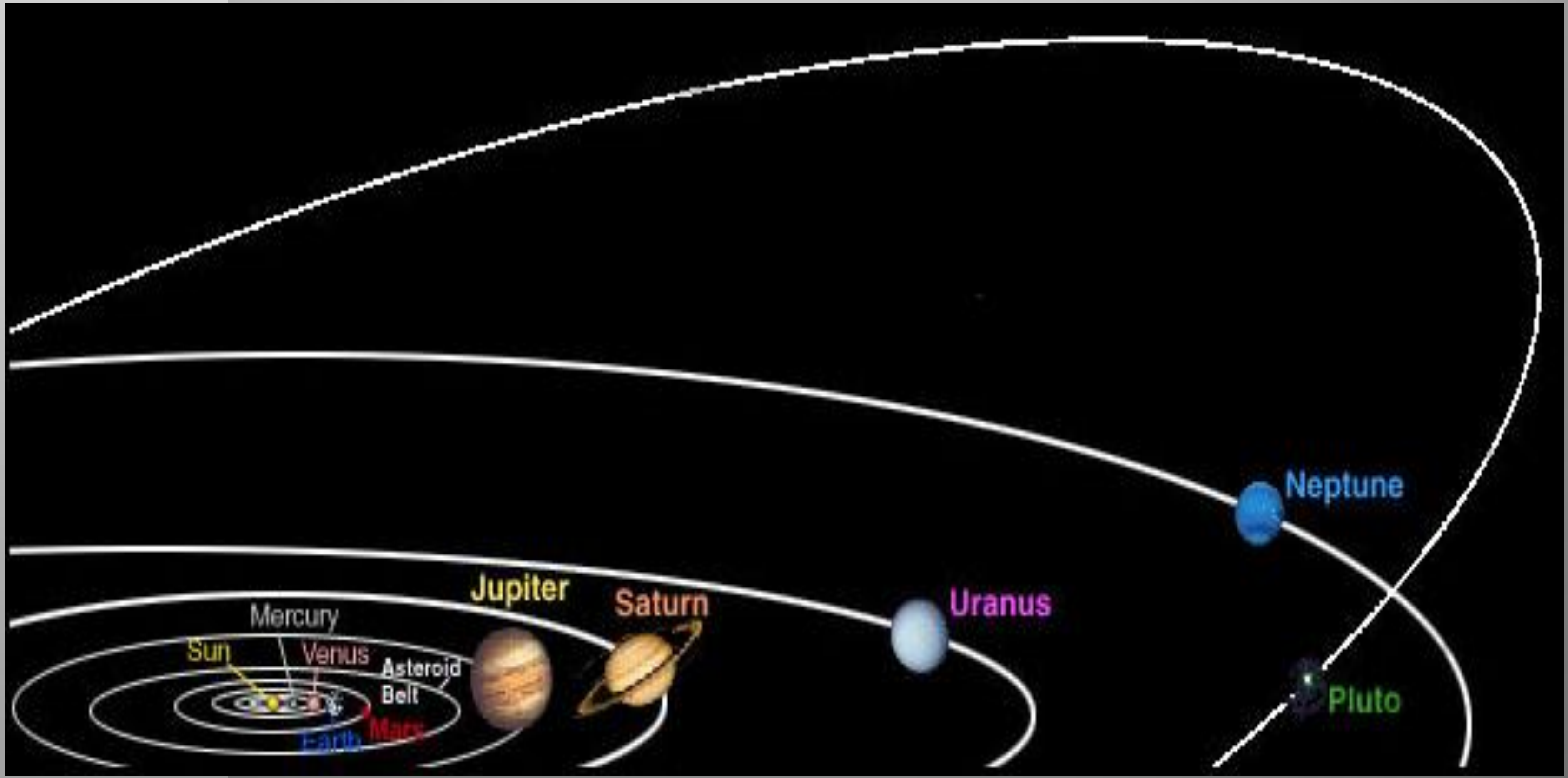
Nebular Condensation: Step 2



Nebular Condensation: Step 3



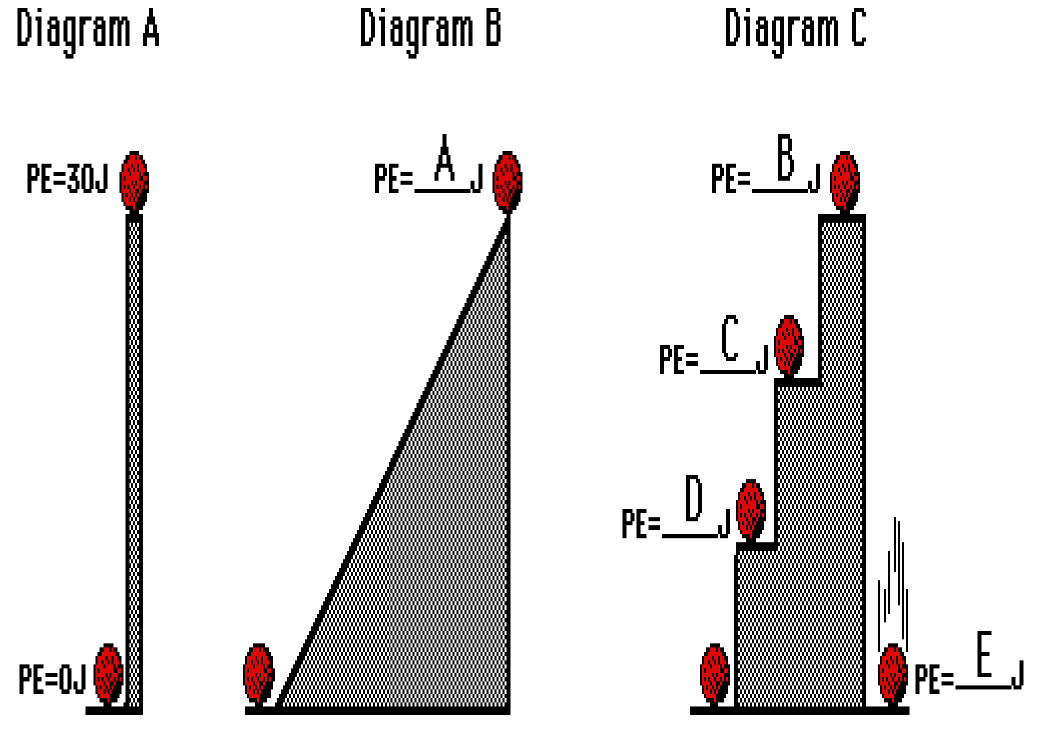
Our Home Planet
(one of the Nebular Rings)



The Earth is HOT!!

- **How did the Earth get so hot when the nebular condensation hypothesis predicts a cold beginning?**

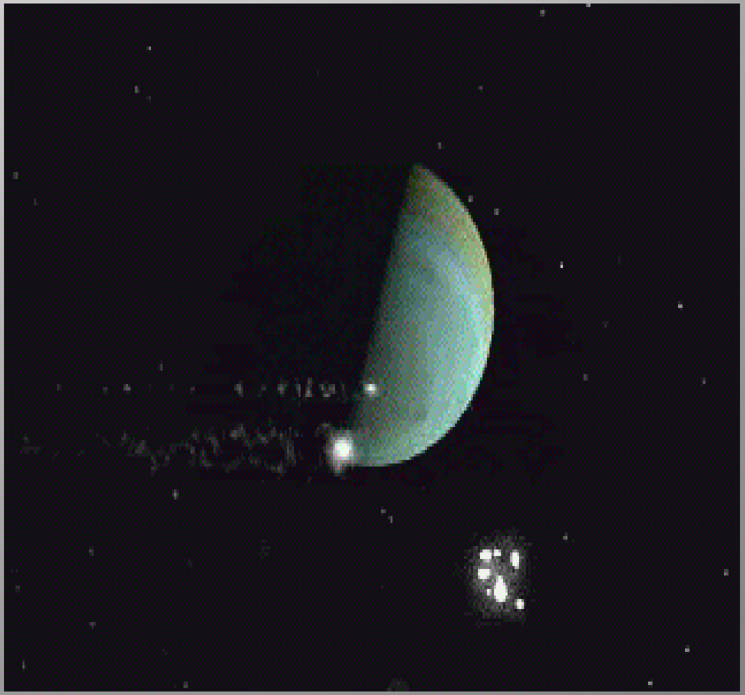
Potential Energy Conversion



- **Potential energy can be thought of as stored energy. In the case of gravitational potential energy, the conversion to kinetic (motion) energy is not 1:1 some heat is given off in the process.**
- **P.E.= K.E. + HEAT!!**

Meteorite Impacts on Earth

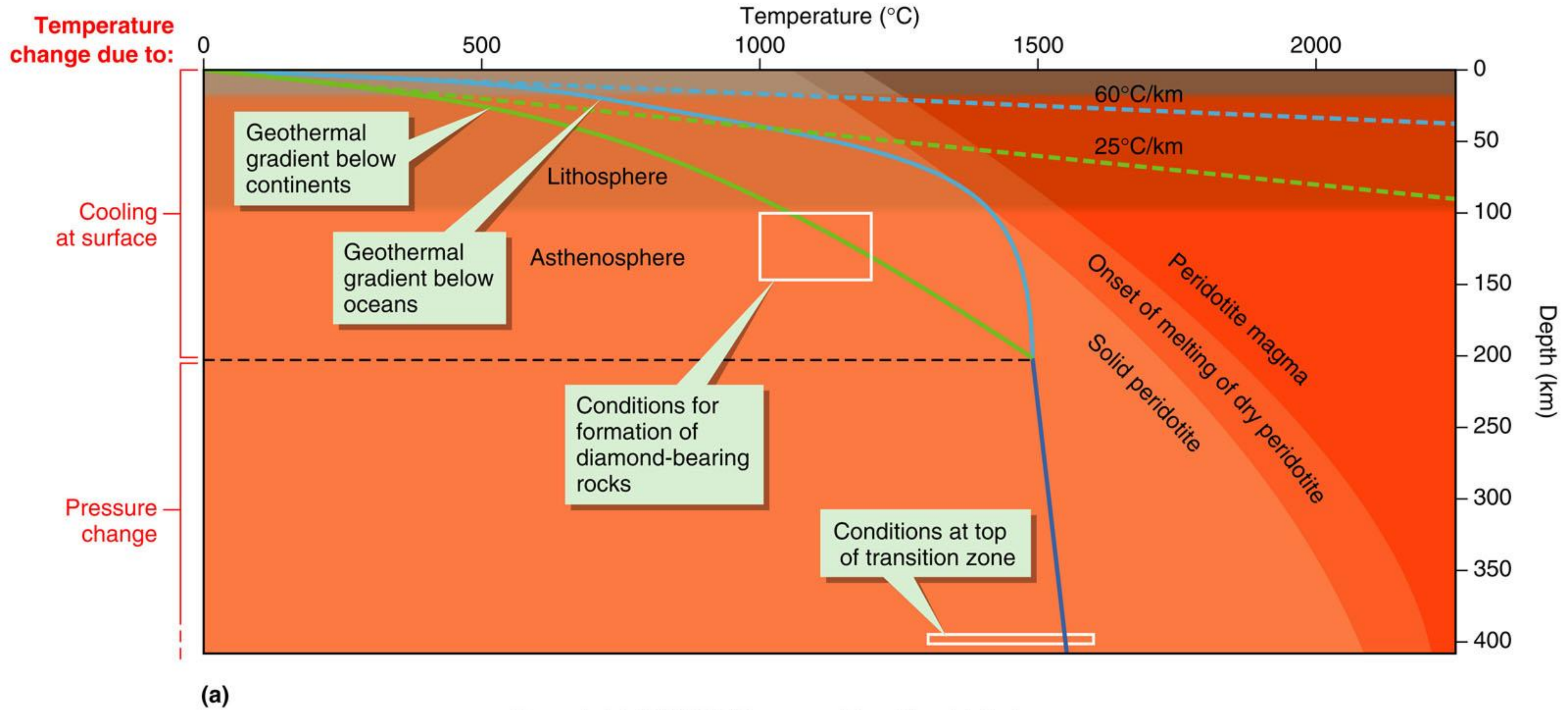
- The Earth coalesced as meteors impacted the Earth.
- Each Impact converted P.E. to K.E. + some heat.
- Frictional energy upon impact also resulted in heat.
- Each meteor contained short-lived radioisotopes such as ^{26}Al. When these decayed additional heat was released.



How hot is the interior of Earth?

- The geothermal gradient
  - Near-surface 25–30^{o}C in continental crust, and 60^{o}C beneath oceans.
  - If this continued within Earth (say at 30^{o}C) the core would have to be at 200,000^{o}C. This is unreasonable.
  - Therefore, the gradient must decrease with depth.

How hot is the interior of Earth?

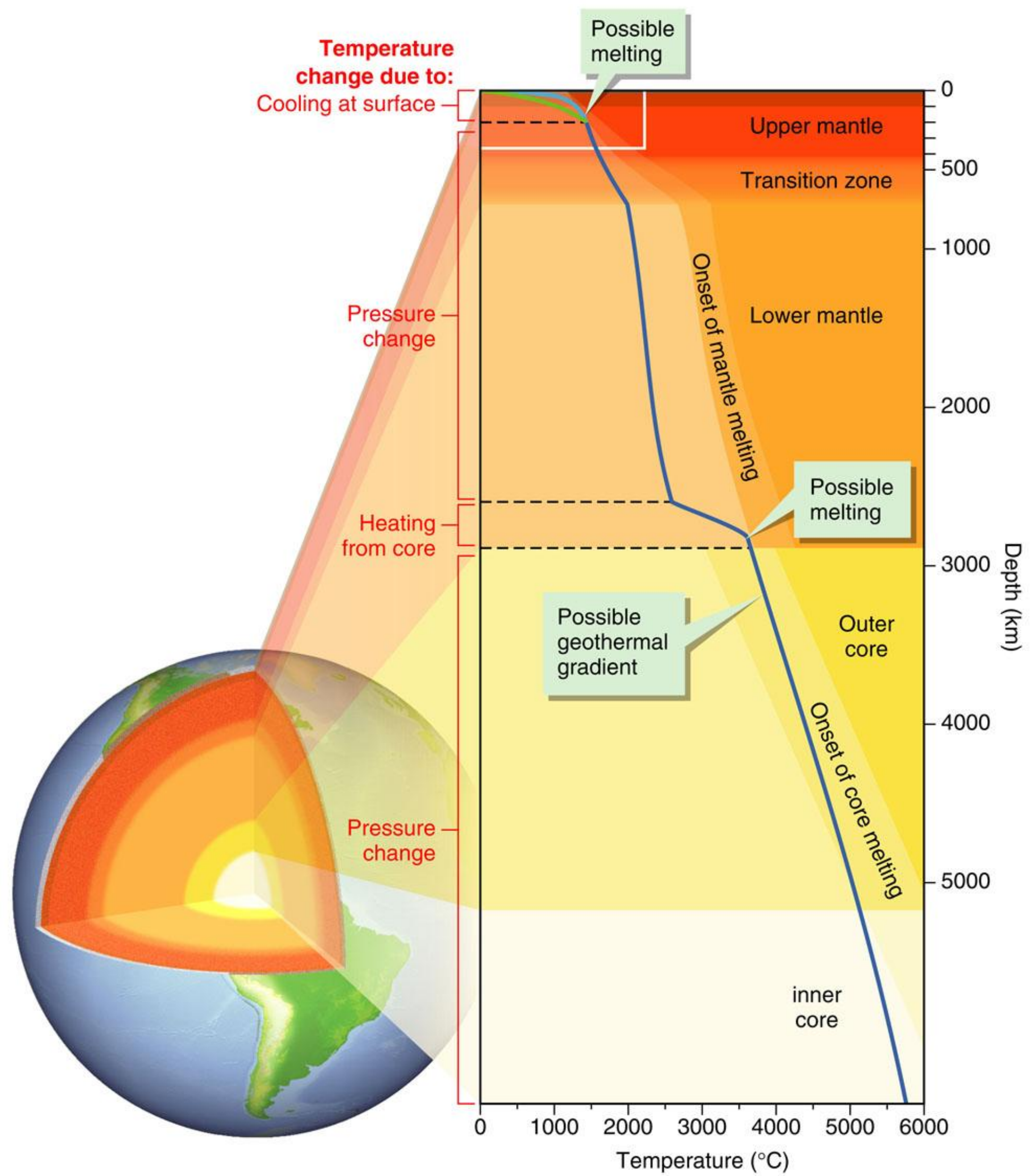


A geologic interpretation of Earth's internal temperature regime. The solid blue line is a speculative gradient for the deeper Earth.

How hot is the interior of Earth?

This continuation of the geothermal gradient down into the deeper Earth to its core shows the transitional zones.

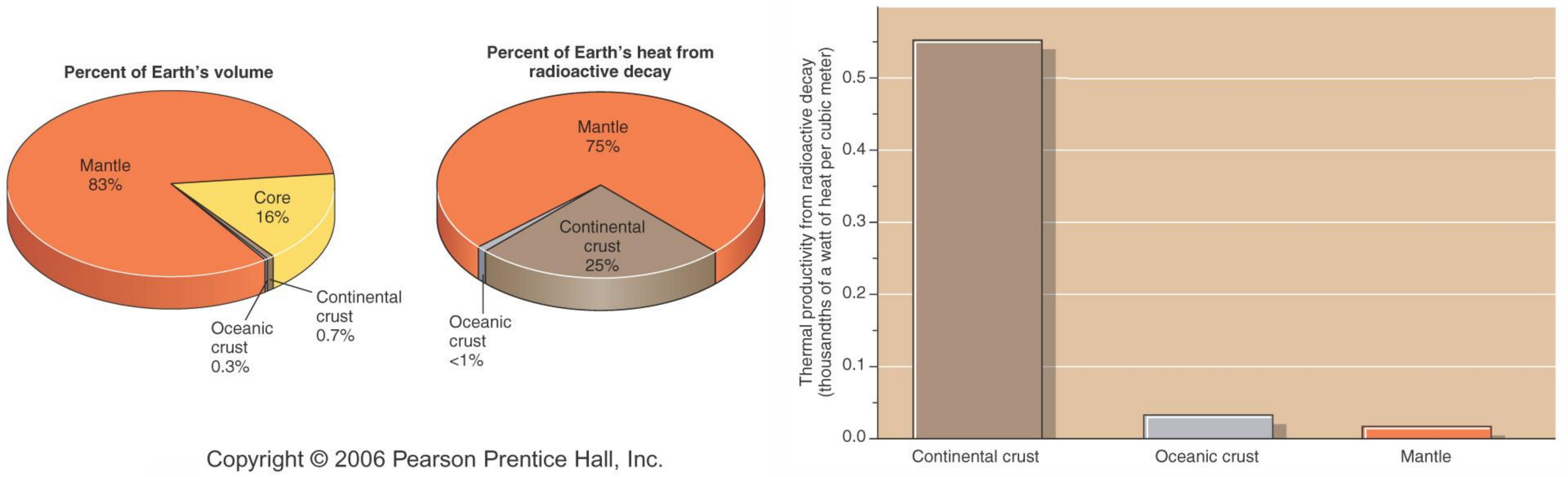
Much of the hypothetical inner Earth gradient is derived from seismic data.



(b)

How hot is the interior of Earth?

Why the interior is hot



Heat must be generated within Earth in order to account for its high internal temperature. This is due in part to radioactive decay of potassium, uranium, and thorium in silicate minerals. However, their volume is not sufficient in the mantle and core to account for Earth's internal heating. This missing heat is from crystallization of iron.

When did all this happen?

- The Earth is about 4.5 Billion years old as are the other planets in our solar system (we will explain how we know in a later lecture).
- The earth contains heavy elements such as Fe (iron). What does this tell you about interstellar space around us.

Where are all those meteors?

- If I promised to give you an A if you could return with a meteorite within 5 minutes, could you do it?
- Most meteorites are Fe, Ni metallic bodies.
- Where could you go today to find evidence for a meteor impact?

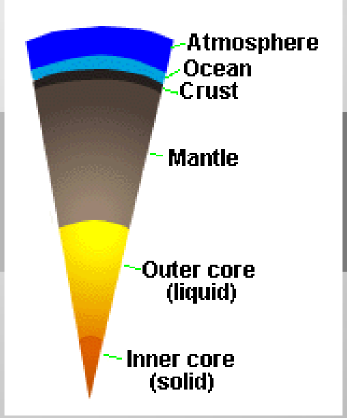
Summary

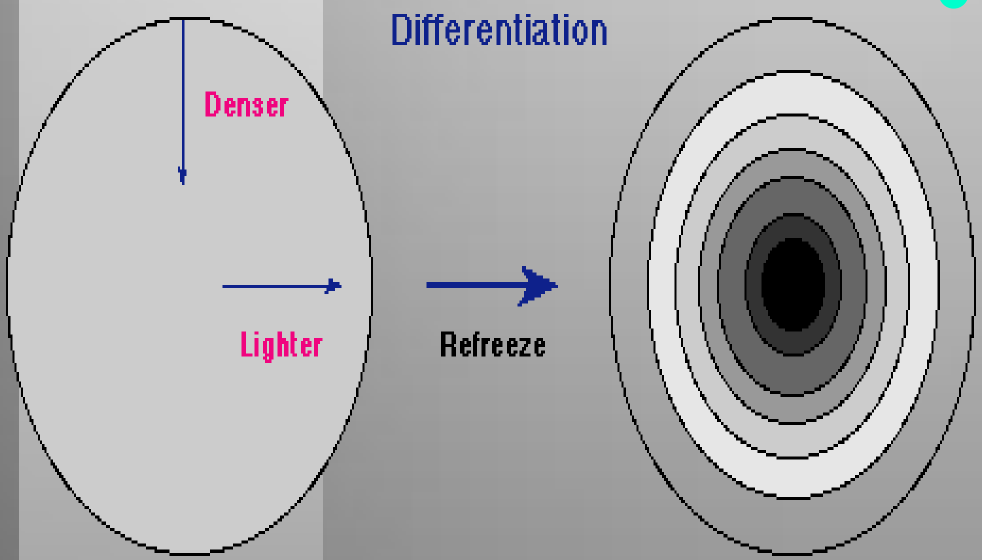
- Solar System Formed via nebular condensation and gravitational accretion.
- Early Earth (proto-Earth-stage) was relatively cold.
- As the proto-Earth grew, it began to heat up via accretionary energy, decay of short-lived radioisotopes and frictional energy (due to impacts).
- About 4.5 billion years ago, the earth was largely molten.

Early Earth Processes

- **The resulting liquid had variable density resulting in *immiscibility*.**
- **The *“Iron Crisis”* refers to a time during Earth history ~ 4.5 billion years ago, when all the heavy stuff sank to the center of the Earth.**
- **Thought Question: What happened as this material sank to the center?**

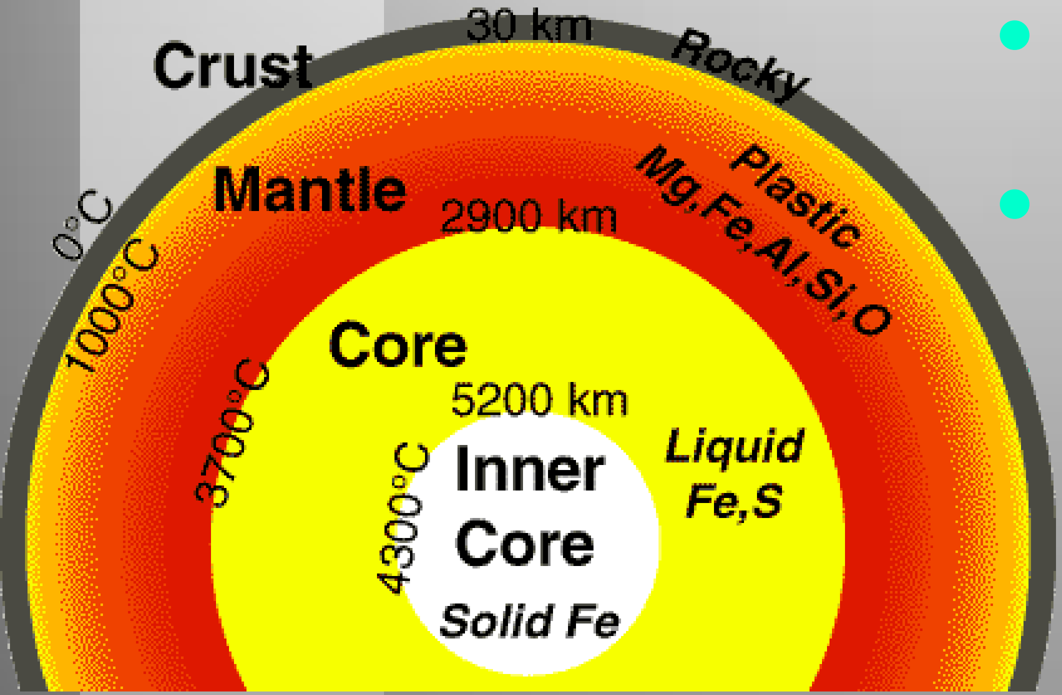
Differentiation





- Differentiation means to separate based on physical or chemical properties. A good example is gasoline and water. These materials separate based on the difference in density. Which is less dense?

What does the inside of the Earth look like?



- Inner Core: Solid Fe, Ni, S
- Outer Core: Liquid Fe, Ni, S

Mantle: Mostly solid Fe, Mg, SiO_2

Crust: Solid Fe silicate (ocean) and Al-silicate (continents)

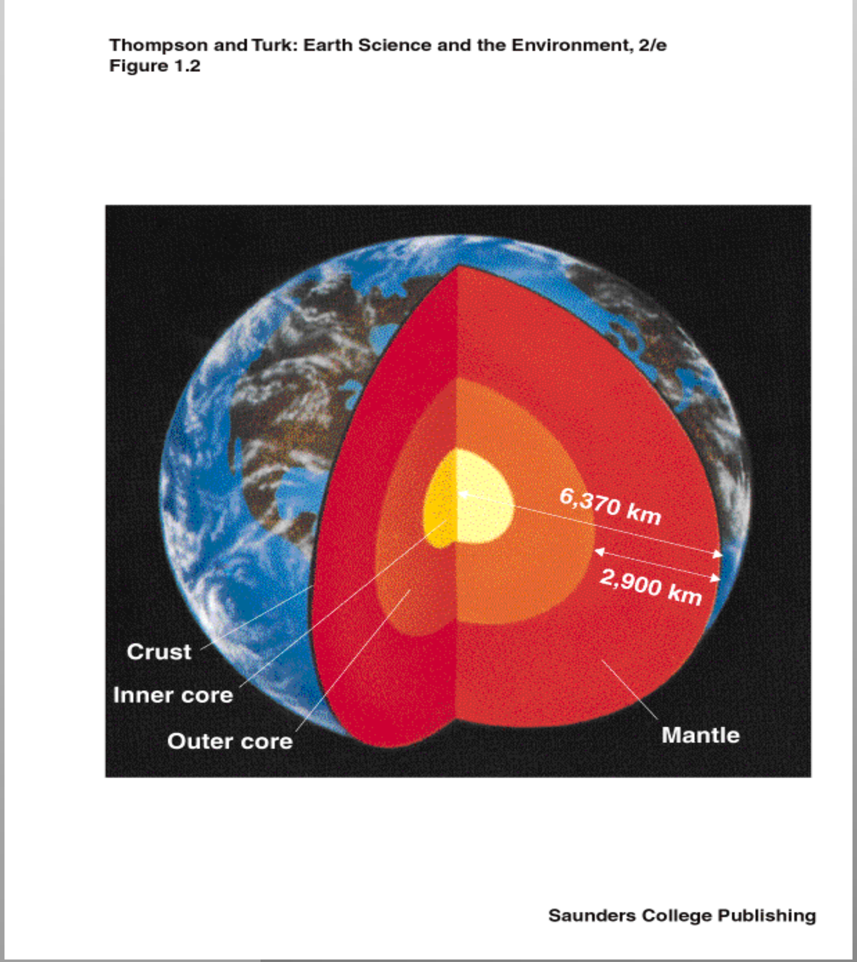
What is the deepest scientists have drilled?

Total Thickness of the Earth is 6370 kilometers.

Answer:

Only about 12 kilometers (8 miles). This leads to another more interesting question about the interior of the Earth.

How did we figure this all out?



- **How do we know that this is what the Earth looks like if we have never drilled more than 12 km?**

Can We Weigh the Earth?

- **Unlike Atlas, we cannot carry the globe on our shoulder and estimate the weight of the planet; however we have at our disposal a bunch of mathematical tools.**
- **Does determining the weight help us at all?**

Gravity and Mass of the Earth

- **A very important formula can help us determine the weight of the Earth.**
- $F_g = GM_e/r^2$
- **What does this mean?**
- F_g**= force of gravity**
- M_e**= mass of earth**
- **R= radius of the earth**
- **G= Gravitational Constant**

What do we know?

- **We can measure the acceleration of gravity on Earth F_g=9.8 m/sec^2**
- **We can determine the distance from the center of the Earth to an object (r^2)**
- **We can measure the Gravitational constant…**
- **So, re-arranging our equation we get M_e= (F_g x r^2)/G**

Does knowing the weight answer our question?

- **Does this information tell us exactly how the earth is layered?**
- **What we want to know is how the Earth packs the material inside. This is known as density.**

What is *density*?

- $\rho = m / v$
- ρ= density
- m= mass
- V = volume

- Density tells you how much mass is packed into a given volume.

- What do we know?
- We just calculated the mass.
- The volume of a sphere can be determined using the formula:

$$\frac{4\Pi r^3}{3}$$

- We know r = radius of the Earth so we can measure the density of the Earth…..

Average Density of the Earth…

- *5.5 gms/cm^3*

Let’s check that 5.5 gms/cm^3 against Earth Materials

- **Rocks collected from the continental crust average**
- **ρ = 2.7 gms/cm^3**

Granite: Llano Uplift, Tx.

Oceanic Crust

- **Rocks collected from oceanic crust average**
- **ρ = 2.9 gms/cm^3**

'Fresh' basalt Hawaii

Mantle Rocks

- Rocks from the mantle collected on the surface average:
- ρ = 3.1-3.3 gms/cm^3

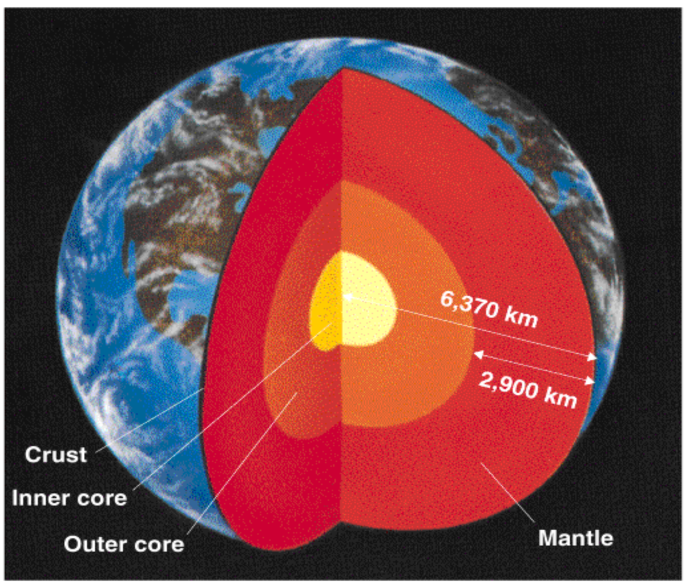
Dunite (Thetford Mines, Canada)

Now some simple addition

- **Mantle (3.1) + Continent (2.7) + Ocean(2.9) / 3 =**
  - **2.9 gms/cm^3**
- **Notice this does not equal <u>5.5 gms/cm^3</u> that we determined a short time ago.**
- **What does that tell us about the deep innards of the Earth?**

There must be something heavier below the mantle!!

Thompson and Turk: Earth Science and the Environment, 2/e
Figure 1.2

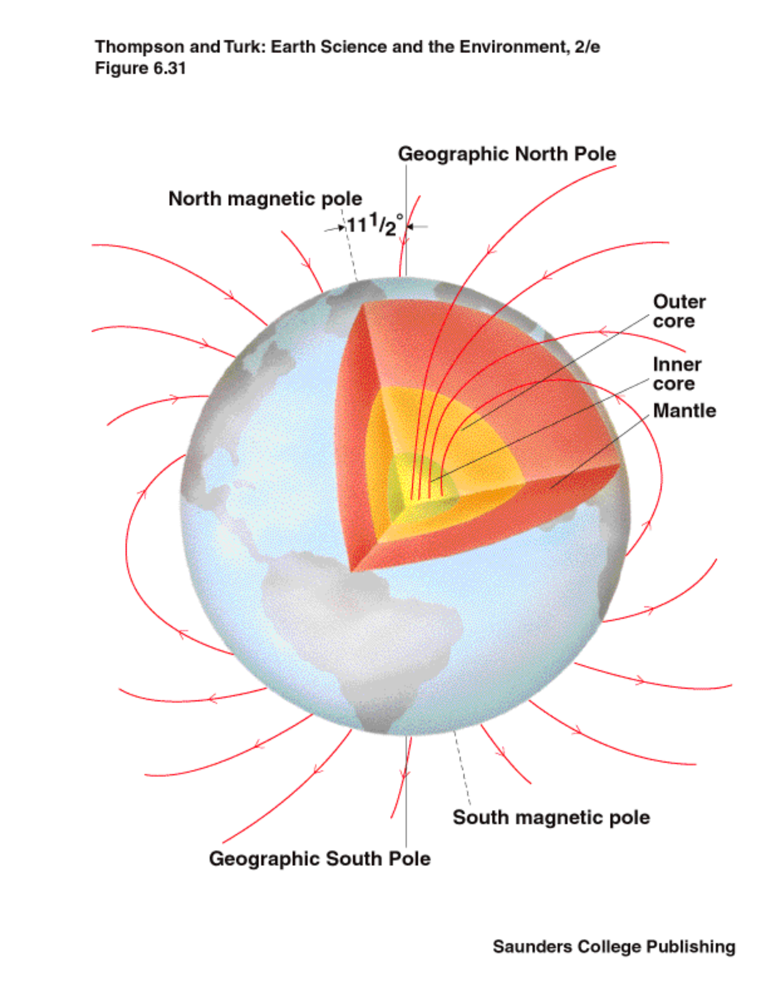


Saunders College Publishing

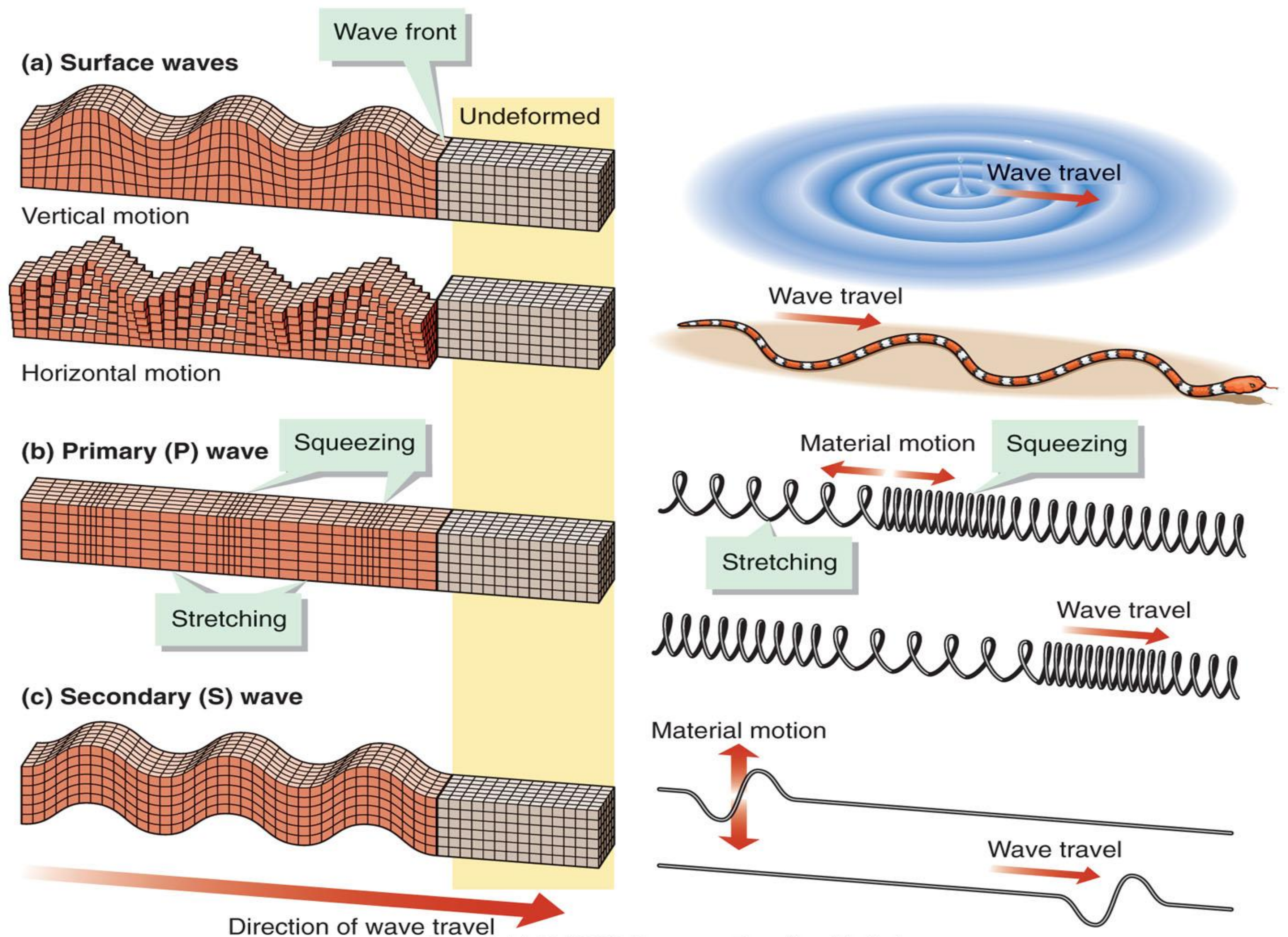
- What are the best candidates?
- Fe, Ni and S
- What do we know that has that chemical makeup?
- Meteorites!!

Other Evidence for the Interior

- **Seismology or Earthquake waves allow us to 'see' inside the Earth indirectly.**
- **The Earth has a magnetic field and Fe is strongly magnetic.**

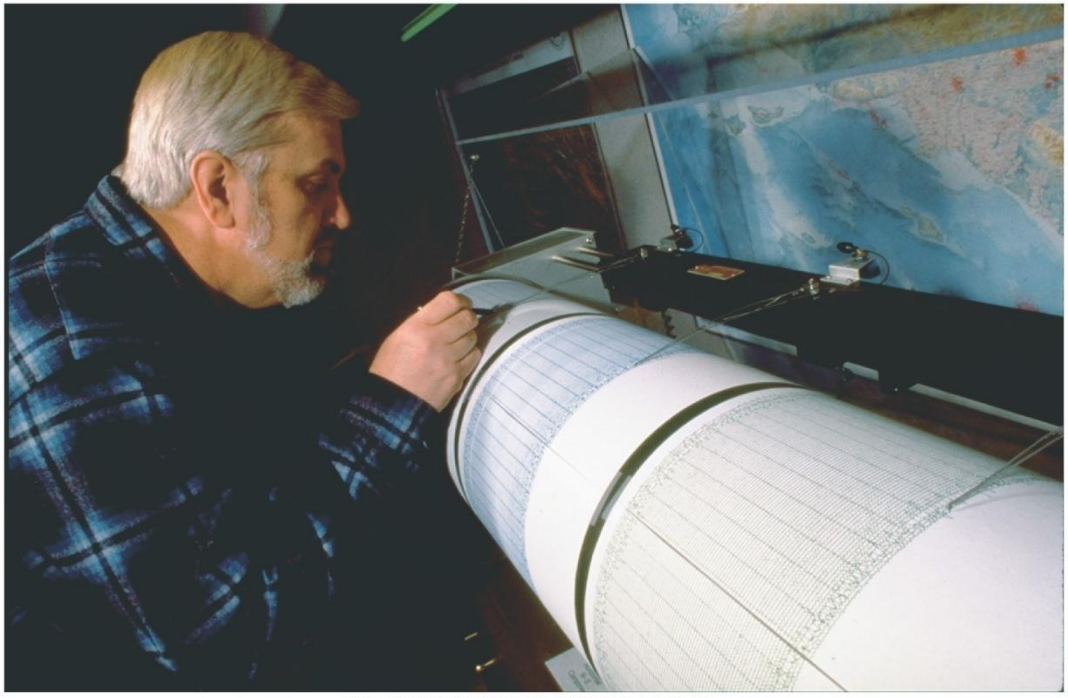


How earthquake waves move through rock

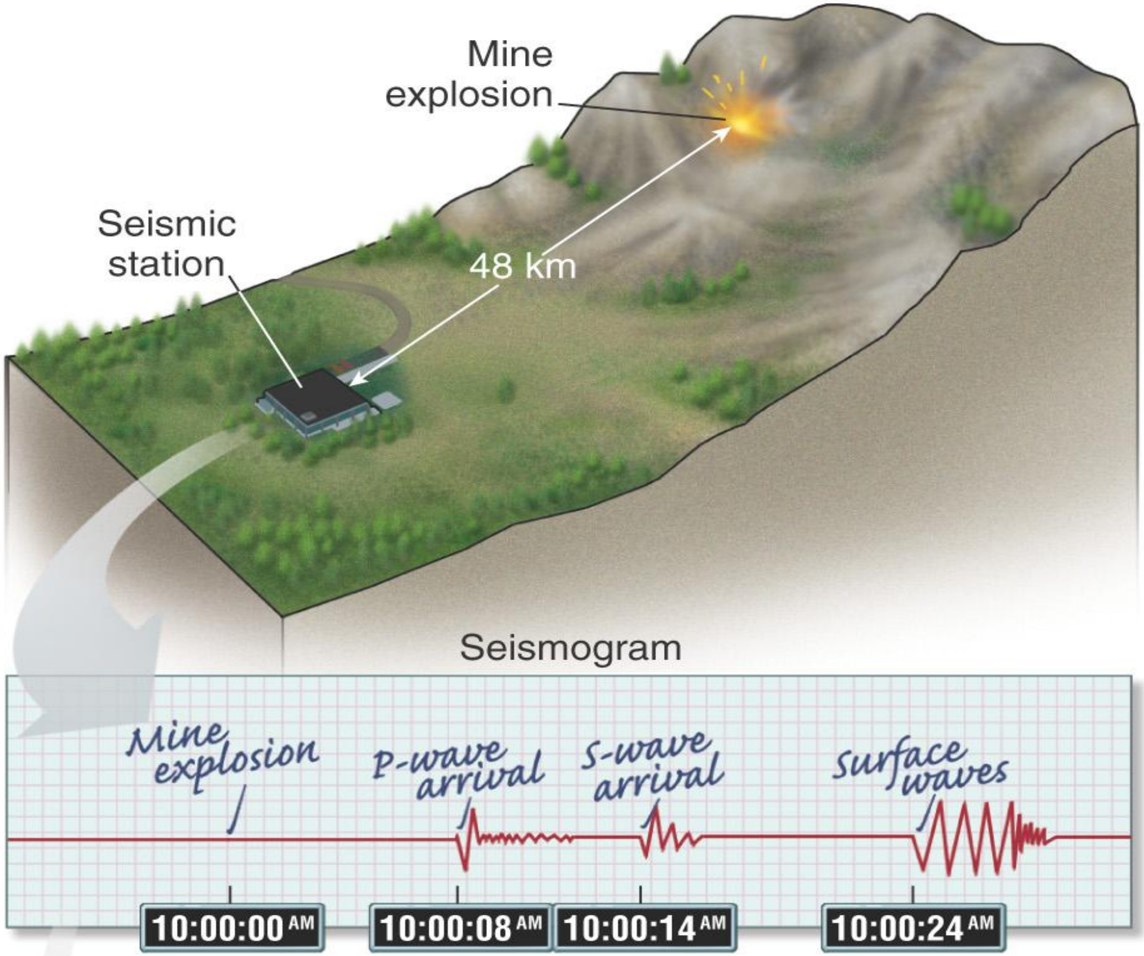


How do earthquakes help make images of Earth's interior?

- **P and S waves travel at different velocities.**
- **So the further from a "disturbance" we measure, the further apart in time the P and S waves will be recorded.**



Determining the velocity of earthquake waves



A seismic station records body and surface waves produced by a precisely timed mine explosion.

The seismogram shows the recorded arrival times of P, S, and surface waves from the mine explosion.

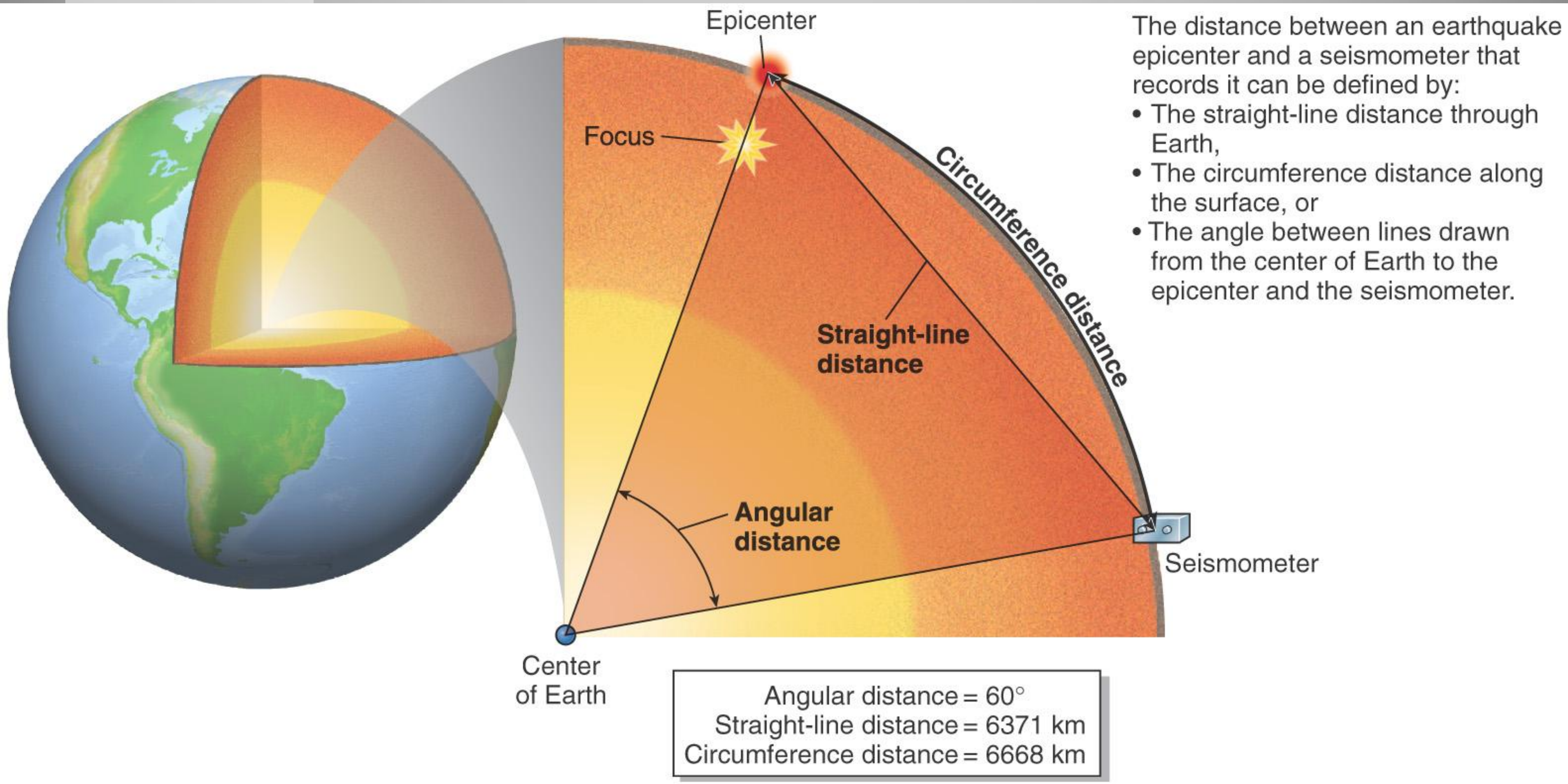
$$\text{P-wave velocity} = \frac{48\ \text{km}}{8\ \text{sec}} = 6.0\ \text{km/sec}$$

$$\text{S-wave velocity} = \frac{48\ \text{km}}{14\ \text{sec}} = 3.4\ \text{km/sec}$$

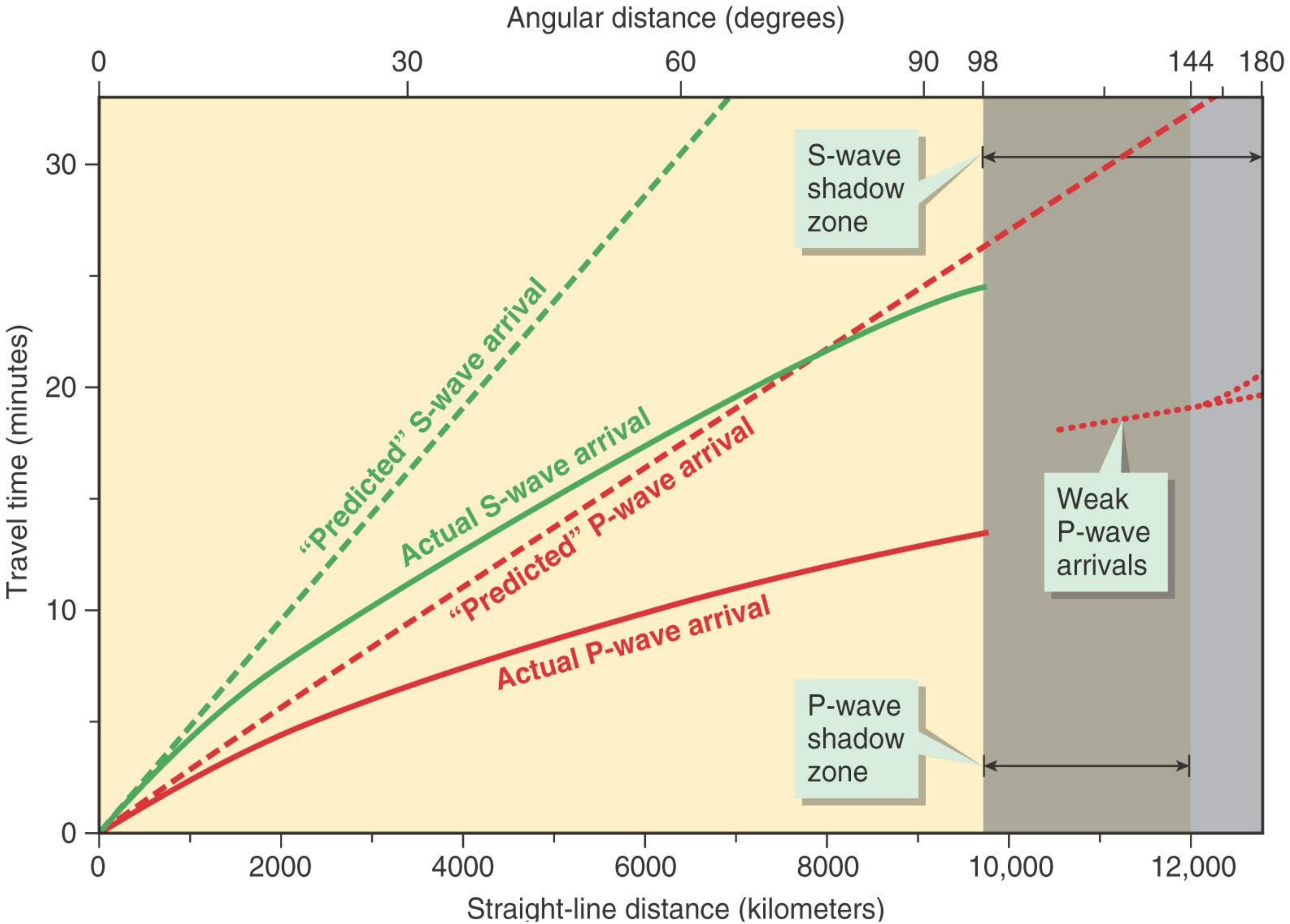
The velocities of the P and S waves are calculated by dividing the travel distance by the travel time.

How do earthquakes help make images of Earth's interior?

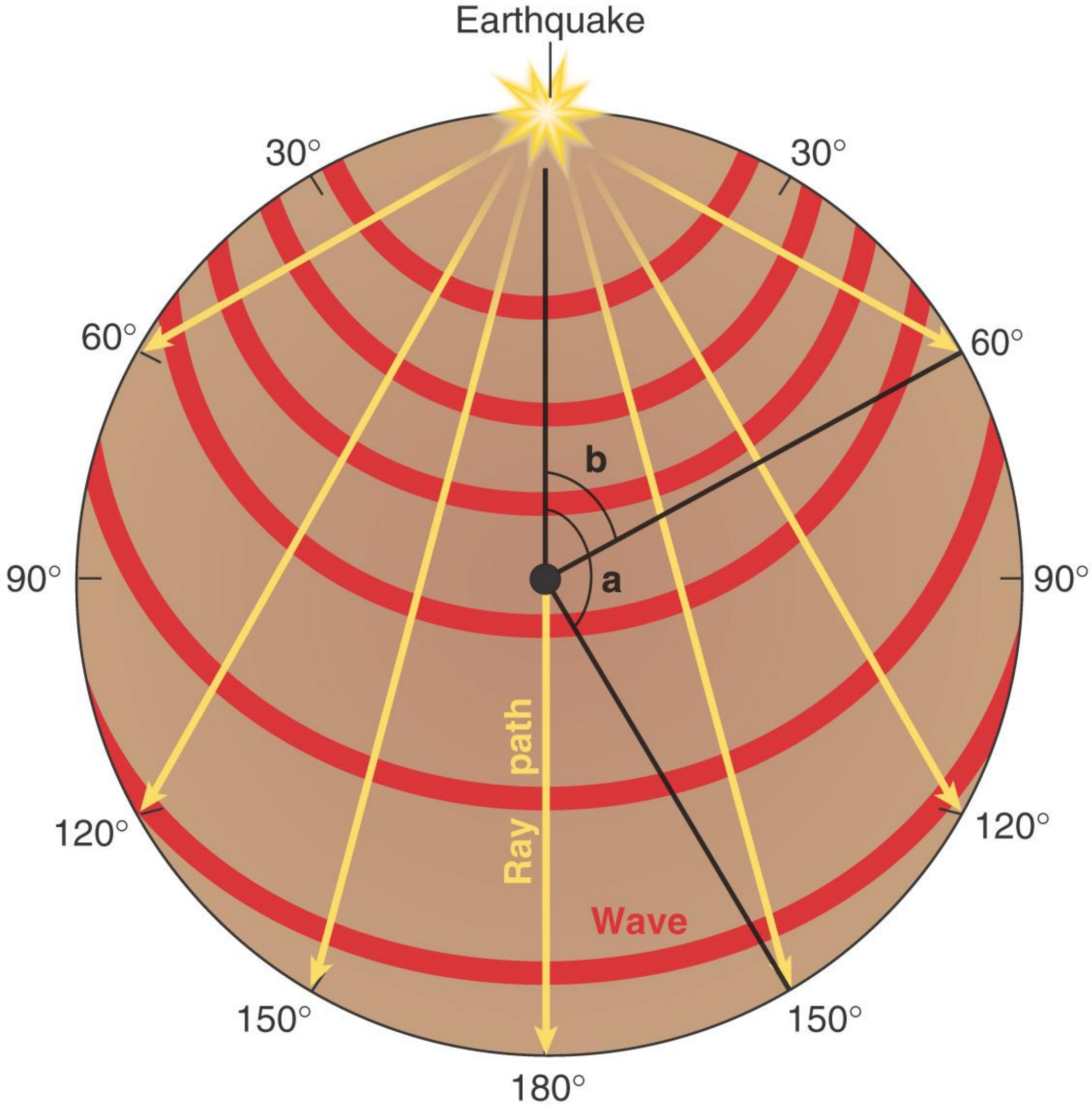
Here we can visualize that measuring the time it takes for a wave to arrive gives us a measure of distance if we know how fast the wave travels.



Earthquake wave time-travel curves

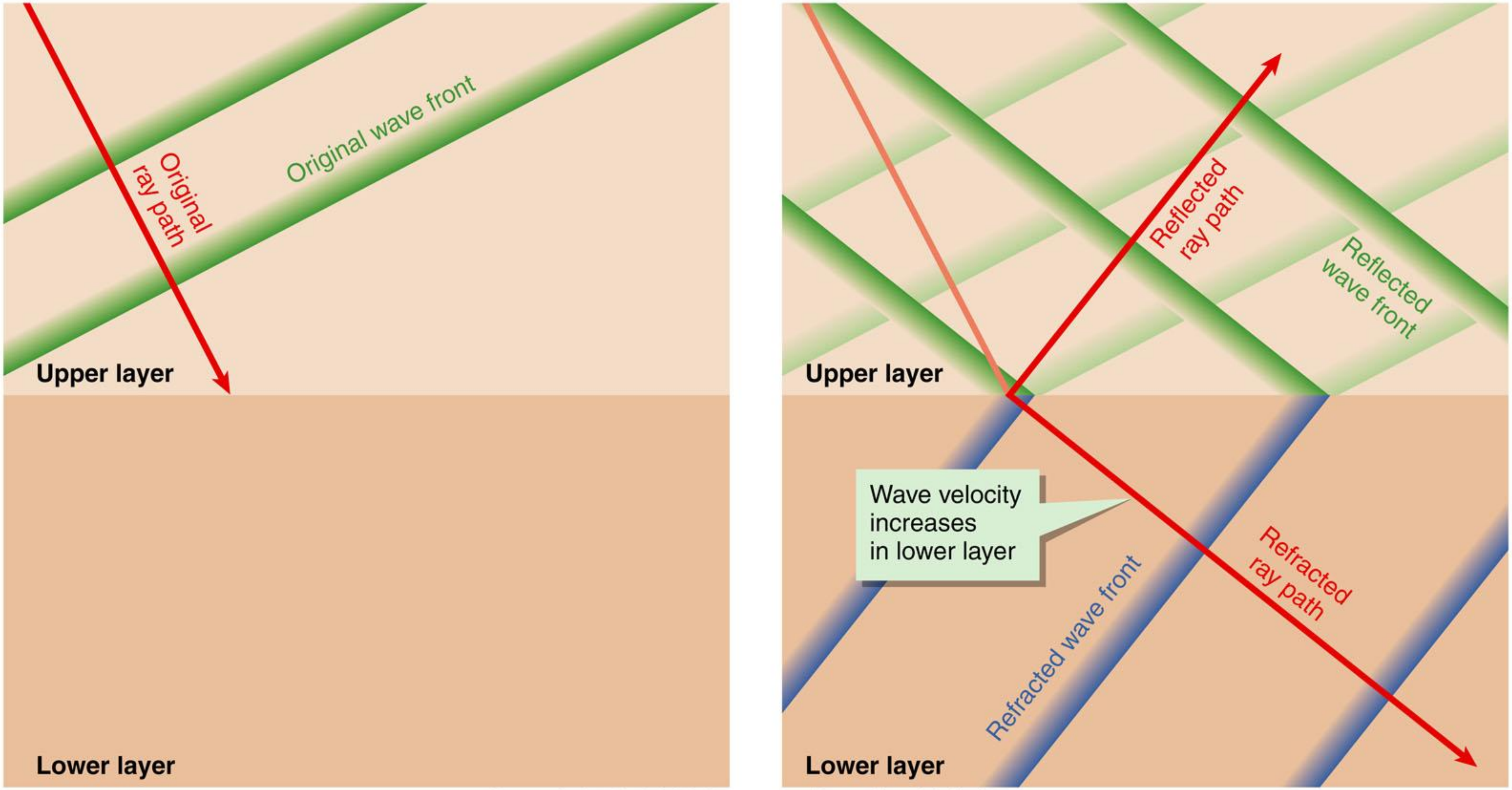


How do earthquakes help make images of Earth's interior?



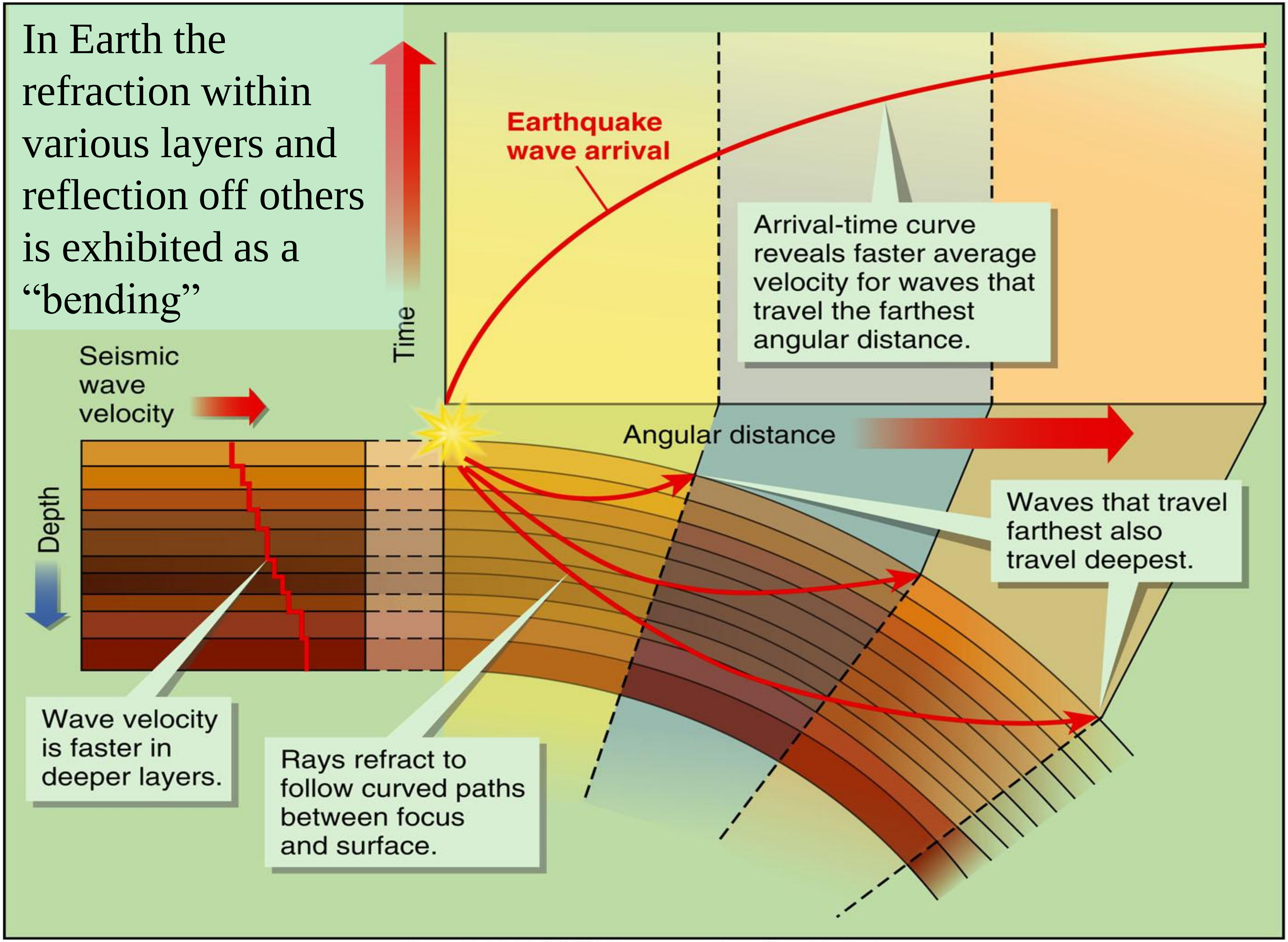
Careful measurements of waves traveling through Earth show that the waves travel faster through some portions than through others, especially through surface materials versus interior rock. This means that physical properties of surface rock are different from deeper rock.

How do earthquakes help make images of Earth's interior?



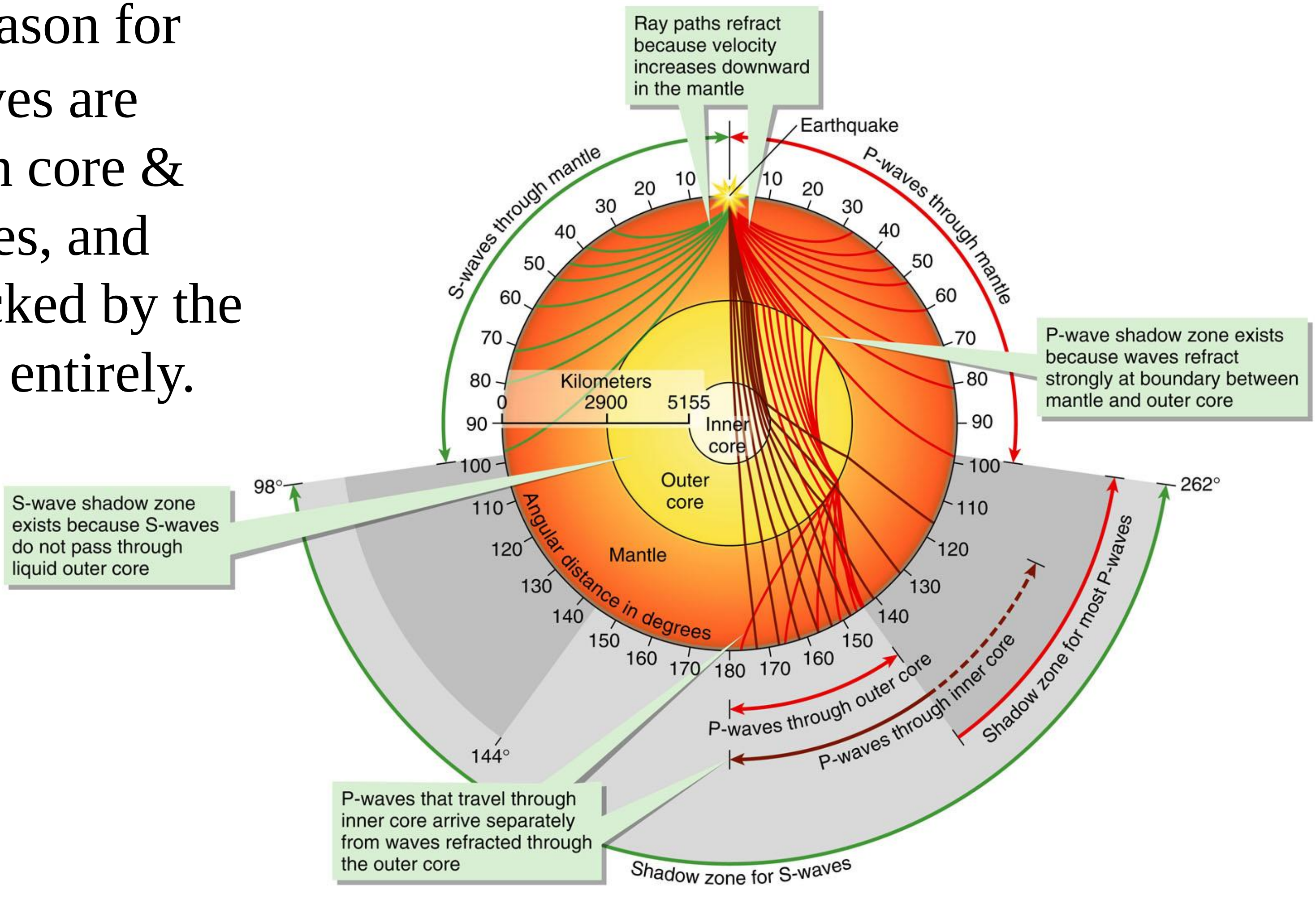
Waves reflecting and refracting off a boundary

In Earth the refraction within various layers and reflection off others is exhibited as a "bending"



How do earthquakes help make images of Earth's interior?

Shadow zones are areas where seismometers do not record P or S waves (or both). The reason for this is that P waves are refracted through core & mantle boundaries, and S waves are blocked by the liquid outer core entirely.



How do earthquakes help make images of Earth's interior?

- Earthquakes produce surface waves, and body waves: P (primary) and S (secondary) that travel through the planet. P and S waves reflect and refract when encountering boundaries with materials.
- Seismograms are records of earthquake waves detected by seismometers. The time needed for these waves to reach the instruments reveals their velocity.
- Travel-time curves reveal that, in general, seismic wave velocity increases deeper into Earth. Shadow zones where S, P, or both waves are not recorded reveal that Earth has a liquid center surrounding a solid inner core at 5155–6371 km depth.