The Interior of the Earth
PS 100 Chapter 27
When the gravitation constant G was determined so was the density of the earth. It is 5.5g/cc. Granite is 2.7

Canadian Shield
• The Canadian Shield is typical
  – Covers 1/4 of NA, over 3 million km²
  – Basic structural features well exposed
    • Relief is up to 100 m
  – Shows core of several mountain belts

Stable Platforms
• Sedimentary rock covering a shield

Folded Mountain Belts
• Tight folds, thrust faults, accreted terranes and igneous intrusions & volcanics
  • Appalachian Mountains ridge & valley province classic example
**Features of the Ocean Basin**

- **Bathymetry:**
  - Topography of the ocean floor

some more review.

A quiz and a story

Have you ever looked a map of the world and thought that the two sides could fit together?

A. Yes  
B. No.

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**Continental Shelf**

- Mid-Ocean Ridge
- Abyssal Plain
- Continental Slope & Rise

**Sea Floor Topography:**

- Shelf
- Slope
- Rise
- Abyssal Plains & Hills

*Most abundant landform on Earth*

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The topographic features known as abyssal hills characterize >30% of the ocean floor, and yet their origin has been the source of vigorous debate for over 40 years.

- They are typically 10-20 km long, 2-5 km wide and 50-300 m high, are oriented approximately perpendicular to the spreading direction, and cover virtually all of the ocean floor except where they are buried beneath sediment [1, 2, 3, 4].

[Origin of abyssal hills](http://www.odp.tamu.edu/publications/202_IR/chap_11/images/11_f02.jpg)

[www.geol.ucsb.edu/~Nnature/nature.html](http://www.geol.ucsb.edu/~Nnature/nature.html)
Features of the ocean bottom, include all but?

A. Trench
B. Seamounts
C. Mid-Ocean ridge
D. Shield
Quiz: Why is basalt rather than granite at the bottom of the ocean? pp
A. Basalt is denser than granite.
B. Volcanoes in the ocean put out basalt and it spreads out from there.
C. Maybe both.
D. Maybe neither.

Density
- Peridotite less than 45% silica (= SiO₂)
  - (olivine 3.4 g/cm³ 3)
- Basalt 3 g/cm³ 45-55 wt% SiO₂
- Granite 2.7 g/cm³ (169 lb/ft³) 72% SiO₂
- Sandstone 2.3 g/cm³ ~100% SiO₂
- From wikipedia and other sources
Rocks made from pre-existing rocks, by the process of weathering are?

A. Sedimentary
B. Igneous
C. Metamorphic
D. Soft
E. Very expensive

How do we know what’s inside the Earth?
1. Drill a hole... a very deep hole!
2. “Weigh” the earth.
3. “Listen” to earthquakes. (Best)
4. Examine meteorites.
5. Study magnetic properties.

Drilling a Hole
Ocean drilling program

Deepest hole penetrated: 2,111 m (1.31 mi)
Leg 148, E Pacific Ocean
Shallowest water depth: 37.5 m (123 ft)
Leg 143, NW Pacific Ocean
Greatest water depth: 5,980 m (3.72 mi)
Leg 129, W Pacific Ocean

“Weighing the Earth”
(The Cavendish Experiment)
(Sir Henry Cavendish (1798))

\[ F = \frac{GMm}{d^2}, \] so if you know G, m, and F you can figure out the mass of the Earth

348 lb balls of lead

Direct Observations
• Inclusions in Volcanic Eruptions
  • Pieces of rock from deep in the Earth are brought up in “hot-liquid-magma” as it rises to the surface

Added fact:
Kimberlite is rock from ultradepth > 100 km brought up very fast long ago (Diamonds)

Inferences from Meteorites
• Stony Chondrite
• Iron
  Iron & nickel are combined in varying percentages from less than 6% nickel to as much as 75% nickel, although iron is by far more common than nickel
• Stony Achondrite
Why is a magnetic field created in the outer core? [Lines below represent the field.]

- Convection of conductive fluid in the outer core creates the earth’s magnetic field.
- Changes in the pattern of convection lead to changes in the magnetic field.

What is the source of energy to create the seismic waves?

- Energy is released when the tectonic plates move and seismic waves move out from focus of rupture.

What are seismic waves? P waves? S waves?

- P waves travel faster. They refract as shown here!

Which travel faster?

- Uniform density and elasticity
- Gradually increasing density and elasticity

What happens to waves when they move into material that is stiffer or denser?

- S waves will not travel through the outer core.

Why will S waves not travel through the outer core?

- Shadow zone between the dark oval areas.

There are sharp changes in the composition of the earth with increasing depth

- Why will S waves not travel through the outer core?

- Why do P waves slow down and refract in the outer core?

A Real Shadow Zone

- Predicted P-Wave Travel Time
- COCOA
- Shadow zone between the dark oval areas
Seismic waves reveal the more complete picture of the earth’s deep interior...

• Crust
  - 2.7 - 3.0 g/cm³
  - 5 - 30 km thick
• Mantle
  - 3.2 - 5.0 g/cm³
  - 2,900 km thick
• Core
  - 10.8 g/cm³
  - 3,500 km thick

The interior of the earth is a busy place as both the outer core and the asthenosphere convect!

Locating the Quakes Epicenter

• We know how fast P and S waves travel through the crust.
• We know the time difference between the arrival of the P and S waves at a seismic station.

Seismic Waves

• You need 3 seismic stations to locate, or triangulate, the focus of an earthquake
Locating the Epicenter of an Earthquake

San Francisco 1906 had magnitude of 7.7

San Francisco 1906

Fire: San Francisco

Fault scarp left from the 1959 earthquake near Yellowstone

Magnitude 7.5

Jan. 17, 1995 Hyogo-Ken Nanbu Earthquake

Magnitude 7.2
Tokyo 1923
September 1, 1923
Magnitude 8.19
Firestorm and quake resulted in 100,000 dead and 40,000 missing.

Alaska 1964 had magnitude of 9.2

J. C. Penney, Anchorage 1964
Fishing boat carried inland in Resurrection Bay at Seward, Alaska 1964

How active is the Wasatch Fault?
-Wasatch Fault comprised of 10 segments from Nephi to Brigham City
-On average, each segment has a major event every 6,000 years
-On average, a major event occurs every 600 years somewhere on the fault zone
Seismogram from a hypothetical earthquake