Earthquakes, and the Earth Structure
Earthquake and Seismic Waves

- Fault scarp
- Epicenter
- Wave fronts
- Focus
- Fault
P and S waves

A. P waves generated using a slinky

B. P waves traveling along the surface

C. S waves generated using a rope

D. S waves traveling along the surface

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P-waves

Pulses of Compression in Solid and Liquid
S-waves

Shear Distortions in Solid but NOT Liquid
P-waves move through liquid: S-waves don’t
Earthquakes and Seismic Waves

- Fault scarp
- Epicenter
- Wave fronts
- Focus
- Fault
Travel-Time curves
Reflection and Refraction
Refraction: “bending” of waves as the wave passes from one medium to another.
Refraction and Head Waves

“Head Wave”: Refracted Laser path along air/water interface

Laser source

Reflected Laser path in water
Man Made Earthquakes
Refraction in the Earth

Head Waves
Finding the Mantle
**Finding the Mantle**

**P-wave velocity**
- **6 km/sec in crust**
- **8 km/sec in mantle**

- Earthquake
- 30 km
- 10 s
- 15 s
- 20 s
- 5 s
- 10 s
- 15 s
- 18 s

- Crust
- Head Wave
- Mantle
- Moho
Earthquakes and shadow zones
Finding the Core

P- and S-wave Shadow Zone
S-wave Shadow Zone

Outer core is Liquid

S-wave Shadow Zone
Compositional Layers of Earth

- Solid iron inner core (5150–6370 km)
- Liquid iron outer core (2891–5150 km)
- Mantle (40–2891 km)
- Crust (0–40 km)
Seismic Velocity structure of Earth
Seismic Velocity outer 1000 km

P-wave velocity (km/s)

Crust
Lithosphere
Low-velocity zone (LVZ)
Upper mantle
Transition zone
Lower mantle

Depth below surface (km)

FIGURE C.7

Earth: Portrait of a Planet, 2nd Edition
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Today’s structure of the Earth

Solid iron inner core (5150–6370 km)

Liquid iron outer core (2891–5150 km)

Crust (0–40 km)

Mantle (40–2891 km)
Crust vs Whole Earth Composition

Figure 1.7
Copyright © 1998 by W.H. Freeman and Company
<table>
<thead>
<tr>
<th>Time</th>
<th>Description of Universe</th>
<th>Average temperature of Universe</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Point sphere of infinite density</td>
<td>100 billion °C</td>
</tr>
<tr>
<td>0.01 second</td>
<td>radiant energy electrons neutrinos positrons Other fundamental particles</td>
<td>10 billion °C</td>
</tr>
<tr>
<td>1 second</td>
<td>electrons neutrinos Protons and neutrons form</td>
<td>Below 1 billion °C</td>
</tr>
<tr>
<td>1.5 to 4 minutes</td>
<td>Helium and deuterium nuclei</td>
<td></td>
</tr>
<tr>
<td>1 million years</td>
<td>Atoms form</td>
<td>A few thousand °C</td>
</tr>
<tr>
<td>1 billion years</td>
<td>Proto-galaxies</td>
<td></td>
</tr>
<tr>
<td>5 billion years</td>
<td>Primeval galaxies Quasars</td>
<td></td>
</tr>
<tr>
<td>Today, 8 to 20 billion years</td>
<td>Today's galaxies</td>
<td>-275 °C</td>
</tr>
</tbody>
</table>
Earth grows and rounds out earlier.
Homogeneous and Inhomogeneous Accretion Theories for the Differentiation of the Earth

(a) Homogeneous accretion

(b) Inhomogeneous accretion

Silicates  Nickle-iron
4.5 to 4.4 Ga: Differentiation

The Iron Catastrophe
Compositional layers of the Earth

- Solid iron inner core (5150–6370 km)
- Liquid iron outer core (2891–5150 km)
- Mantle (40–2891 km)
- Crust (0–40 km)