Earth's Interior: Big Ideas

- Earth science investigations take many different forms.
- Earth scientists do reproducible experiments and collect multiple lines of evidence.
- Our understanding of Earth is continuously refined.

Structure of the Earth

- seismic velocity depends on the composition of the type of material and pressure
- when waves move from one type of material to another, they change speed and direction
- we can use the behavior of seismic waves to tell us about the interior of the Earth

Reflection, Refraction, & Continuous Refraction

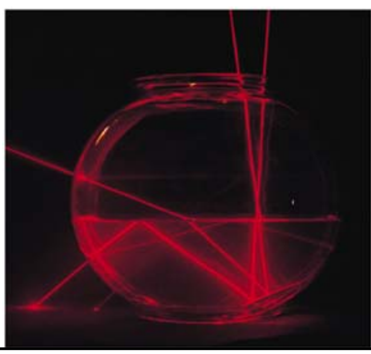


Fig. 14.1

How Do We Know the Earh's Outer Core is a Liquid?

P-Wave Bend at Core-Mantle Boundary

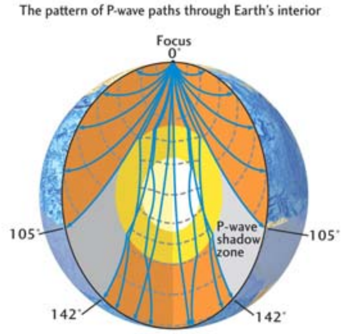


Fig. 14.2

How Do We Know the Earh's Outer Core is a Liquid?

S-Wave Stop at Core-Mantle Boundary

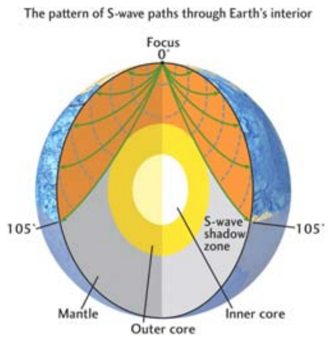


Fig. 14.2

Multiple Paths Give Much Information

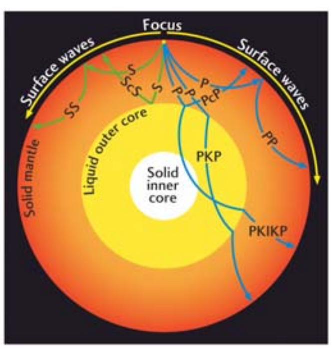


Fig. 14.3

Multiple Waves Give More Information

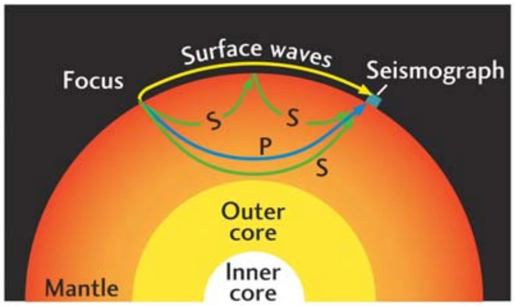


Fig. 14.4

Can Distinguish Waves by Arrival Time and Type of Ground Motion

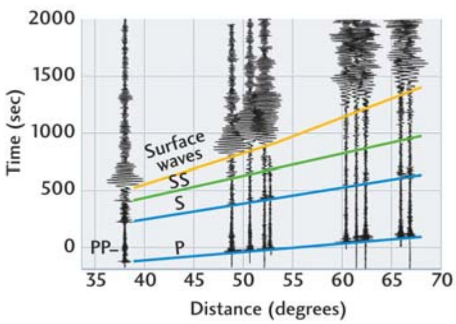


Fig. 14.4

Distribution of Density, Velocity

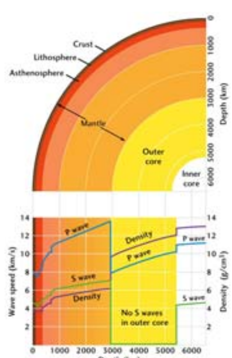


Fig. 14.5

Structure of the Earth

The study of the behavior of seismic waves tells us about the shape and composition of the interior of the Earth:

- *crust*: ~10–70 km thick, intermediate composition
- *mantle*: ~2800 km thick, mafic composition
- *outer core*: ~2200 km thick liquid iron
- *inner core*: ~1500 km thick solid iron

Composition of the Earth

Seismology also tells us about the density of rocks:

- *continental crust*: ~2.8 g/cm^3
- *oceanic crust*: ~3.2 g/cm^3
- *asthenosphere*: ~3.3 g/cm^3

S-Wave Velocity Versus Depth

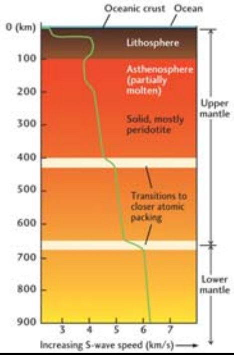


Fig. 14.6

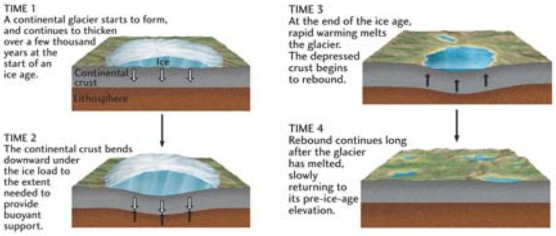
Isostasy

- buoyancy of low-density rock masses "floating on" high-density rocks; accounts for "roots" of mountain belts
- first noted during a survey of India
- Himalayas seemed to affect plumb

Isostasy

In order for continents to be higher they must also be thicker

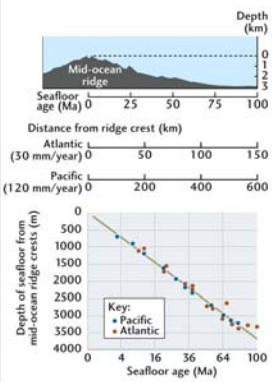
Glacial Rebound



Box 14.1

Earth's Internal Heat

- original heat
- subsequent radioactive decay
- conduction
- convection



The Relationship Between the Age and Depth of the Sea Floor is Fundamentally a Function of Temperature.

Fig. 14.7

Temperature Increases With Depth: The Geotherm Curve

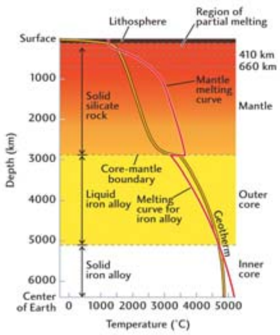


Fig. 14.8

Seismic Tomography Uses Travel Times to Create 3-D Images of Earth's Interior

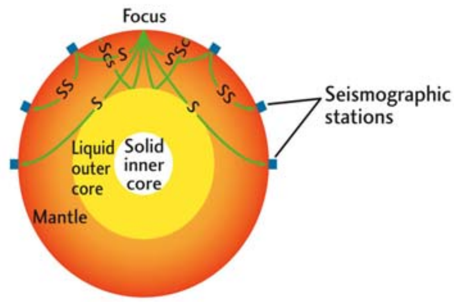


Fig. 14.9

Tomographic Section Reveals Hot and Cold Rocks

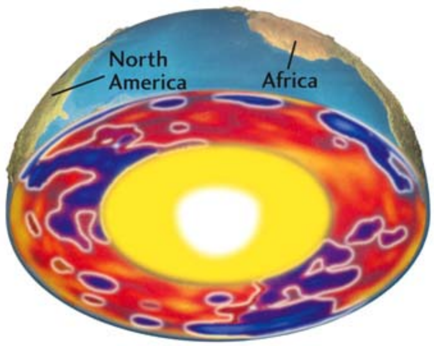


Fig. 14.9

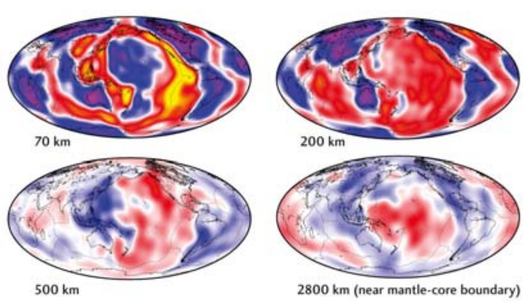


Fig. 14.9

Paleomagnetism

- use of the Earth's magnetic field to investigate past plate motions
- permanent record of the direction of the Earth's magnetic field at the time the rock was formed
- may not be the same as the present magnetic field

Acquiring a Magnetic Signature

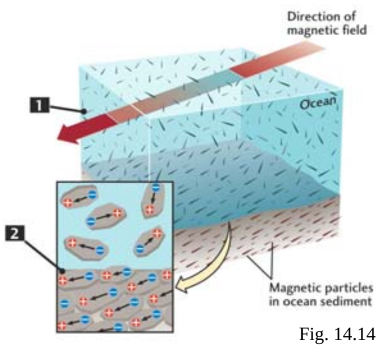
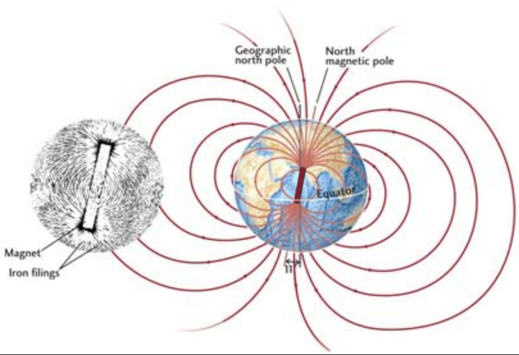


Fig. 14.14

Earth's Magnetic Field

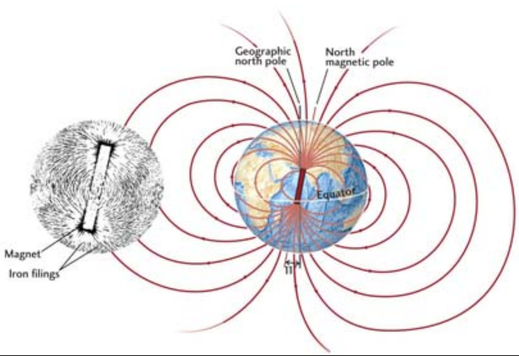


Earth's Magnetic Field

declination: horizontal angle between magnetic north and true north

inclination: angle made with horizontal

What is Inclination at Equator?



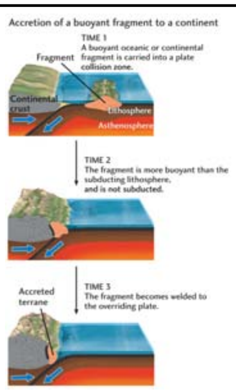


Fig. 10.12a

How Continents Grow: Accretion of Fragments

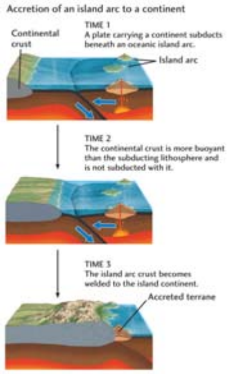


Fig. 10.12b

How Continents Grow:
Accretion of Island Arcs

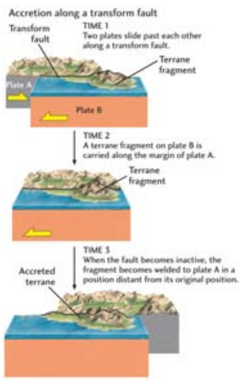


Fig. 10.12c

How Continents Grow:
Accretion Along Transform Fault

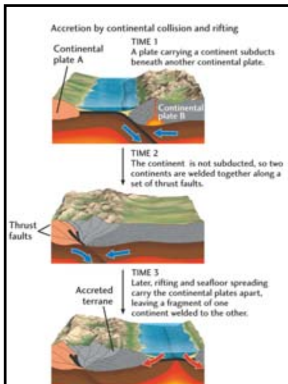


Fig. 10.12d

How Continents Grow:
Accretion by Continental Collision/Rifting

"Suspect Terranes" of Western North America

Multiple accretions of older island arcs, oceanic plateaus, oceanic crust, and marine sedimentary rocks.

Fig. 10.11

Earth's Magnetic Field

- It was first thought that the Earth's magnetic field was caused by a large, permanently magnetized material deep in the Earth's interior.
- In 1900, Pierre Currie recognized that permanent magnetism is lost from magnetizable materials at temperatures from 500 to 700 °C (Currie point).

Geodynamo: Self-exciting Dynamo

A dynamo produces electric current by moving a conductor in a magnetic field and *vise versa.* (*i.e.*, an electric current in a conductor produces a magnetic field)

Geodynamo: Self-exciting Dynamo

• It is believed that the outer core is in convective motion (because it is liquid and in a temperature gradient).

• A "stray" magnetic field (probably from the Sun) interacts with the moving iron in the core to produce an electric current that is moving about the Earth's spin axis yielding a magnetic field—a self-exciting dynamo!

Geodynamo: Self-exciting Dynamo

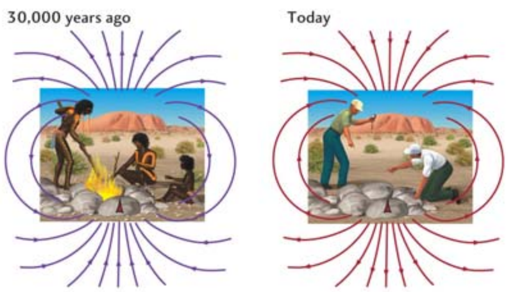
The theory is gaining popularity because:

- it is plausible
- it predicts that the magnetic and geographic poles should be nearly coincident
- the polarity is arbitrary
- the magnetic poles move slowly

Magnetic Reversals

- the polarity of the Earth's magnetic field has changed thousands of times in the Phanerozoic
- The most recent reversal was about 30,000 years ago. However, the end of the last significant reversal was approximately 700,000 years ago.
- These reversals appear to be abrupt, lasting approximately 1000 years.

More Recent Magnetic Reversal



Magnetism and Dating

We can now use the magnetic properties of a sequence of rocks to determine their age.

The Geomagnetic Time Scale

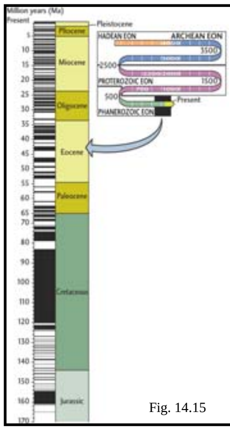


Fig. 14.15

Based on determining the magnetic characteristics of rocks of known age (from both the oceans and the continents).

We have a good record of geomagnetic reversals back to about 60 Ma.