ASTRONOMY

Chapter 8 EARTH AS A PLANET

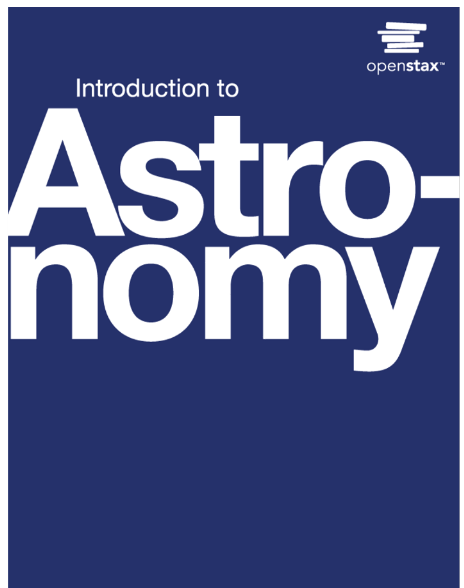

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FIGURE 8.1

Active Geology. This image, taken from the International Space Station in 2006, shows a plume of ash coming from the Cleveland Volcano in the Aleutian Islands. Although the plume was only visible for around two hours, such events are a testament to the dynamic nature of Earth's crust. (credit: modification of work by NASA)

GEOLOGICAL ACTIVITY

Geological activity depends primarily on a world's size:

- because most geological activity is driven by internal heat.

Earth's surface is continually reshaped by

- volcanic eruptions,
- earthquakes and other movements of the crust,
- and by erosion.

SIZE, INTERNAL HEAT, & INTERIOR STRUCTURE

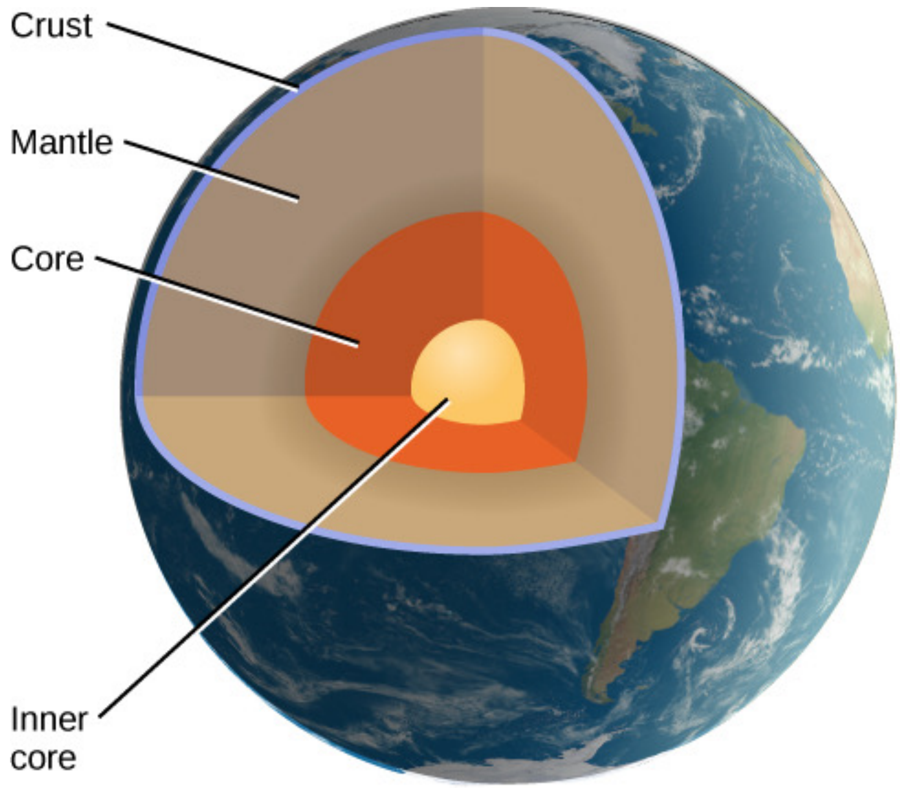
Volcanoes erupt when internal heat melts rock and releases gases that drive the molten rock upward.

Earthquakes occur when heat-driven internal motions cause rock to slip or shift.

All the terrestrial worlds were quite hot when they were young, because accretion of planetesimals converted gravitational potential energy into thermal energy.

Decay of radioactive materials inside the terrestrial worlds later provided additional heat.

FIGURE 8.3



Interior Structure of Earth. The crust, mantle, and inner and outer cores (liquid and solid, respectively) as shown as revealed by seismic studies.

INTERIOR STRUCTURES OF TERRESTRIAL WORLDS

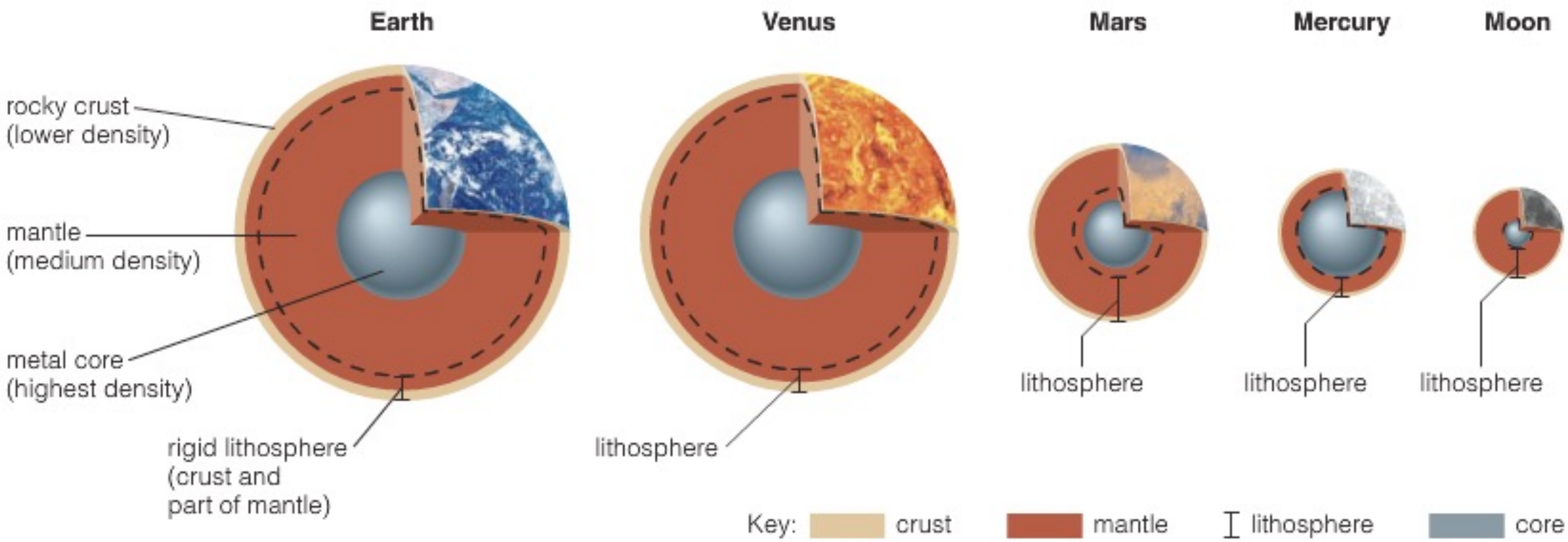


Figure 5.1. Page 77. *The Cosmic Perspective Fundamentals*. Publisher: Addison-Wesley. © 2010

DIFFERENTIATION

Core. The highest-density material, consisting primarily of metals such as nickel and iron, sank to the central core.

Mantle. Rocky material of moderate density—mostly minerals that contain silicon, oxygen, and other elements—formed the thick mantle that surrounds the core.

Crust. The lowest-density rock, such as granite and basalt, formed the thin crust that serves as a world's outer skin.

CONVECTION

Convection: hot material expands and rises while cooler material contracts and falls.

Keep in mind that mantle convection primarily involves solid rock, not molten rock.

Because solid rock flows quite slowly, mantle convection is a very slow process.

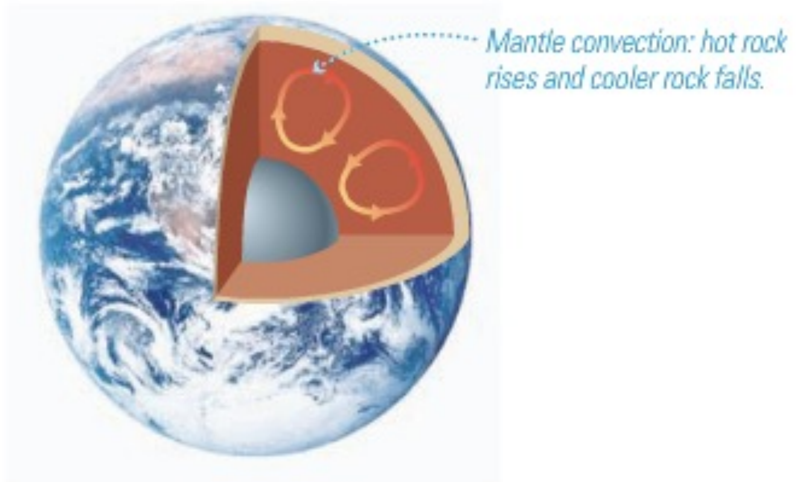


Figure 5.2 | Earth's hot interior allows the mantle to undergo convection. Arrows indicate the direction of flow in a portion of the mantle.

Figure 5.2. Page 77. *The Cosmic Perspective Fundamentals*. Publisher: Addison-Wesley. © 2010

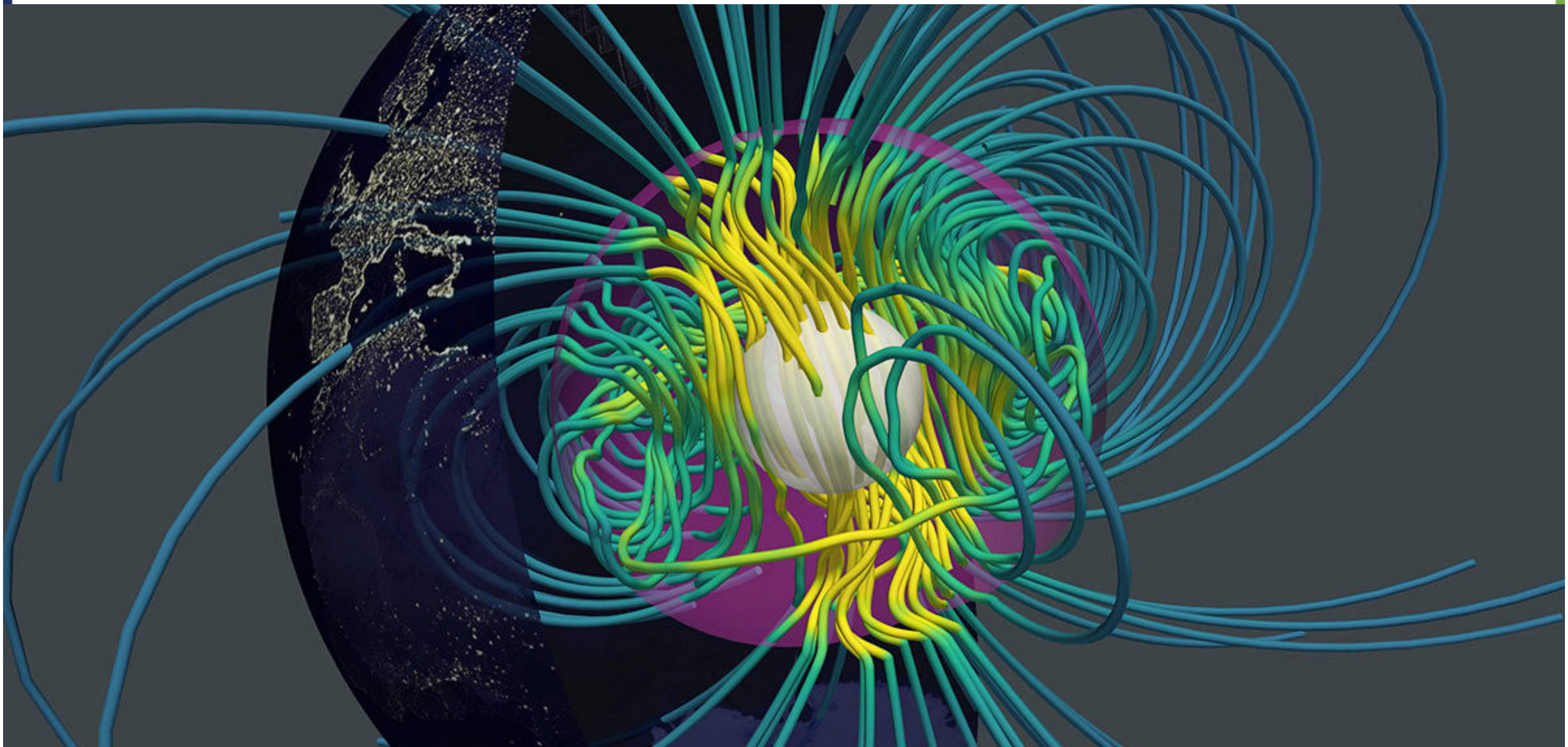
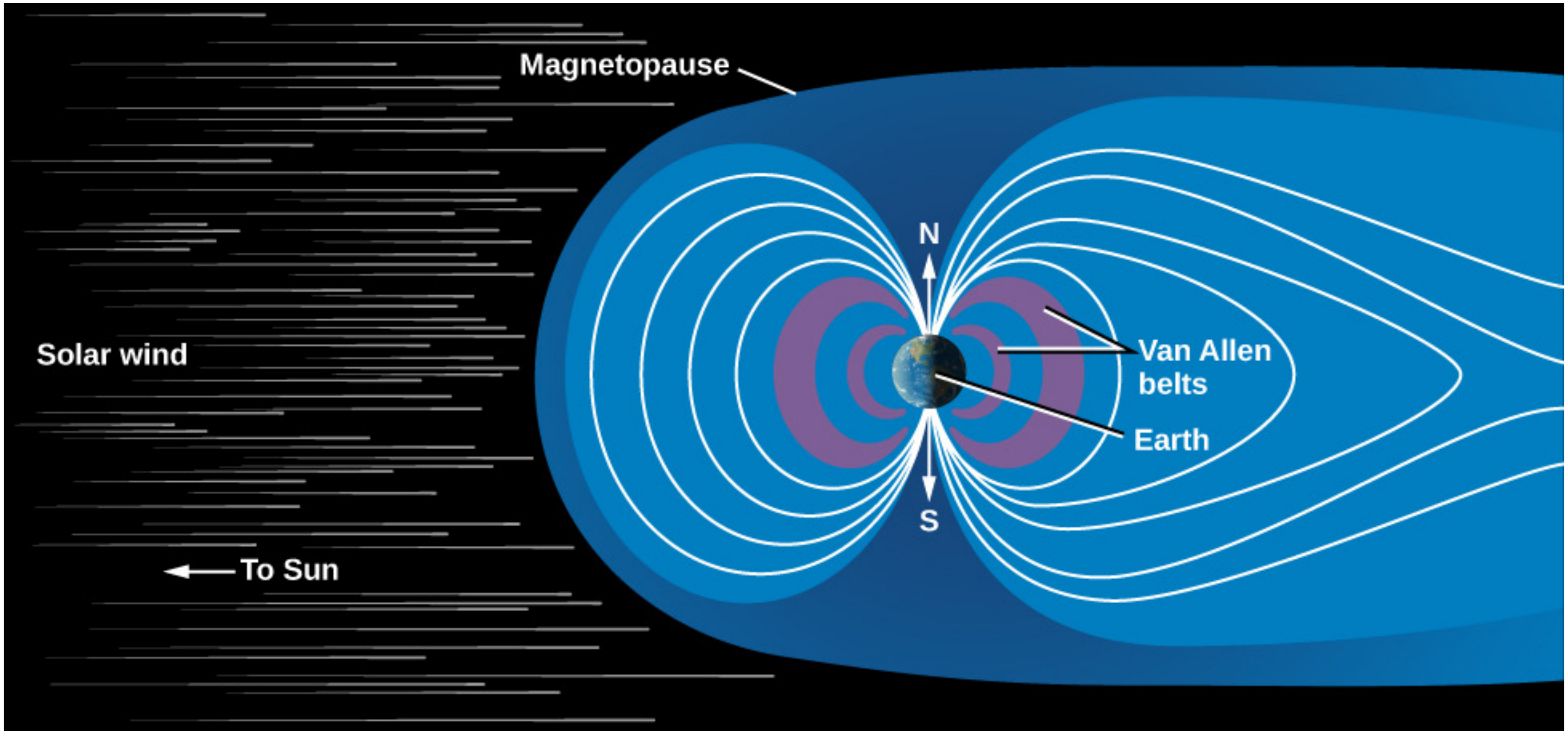


FIGURE 8.5



Earth's Magnetosphere. A cross-sectional view of our magnetosphere (or zone of magnetic influence), as revealed by numerous spacecraft missions. Note how the wind of charged particles from the Sun "blows" the magnetic field outward like a wind sock.

MAGNETIC FIELD

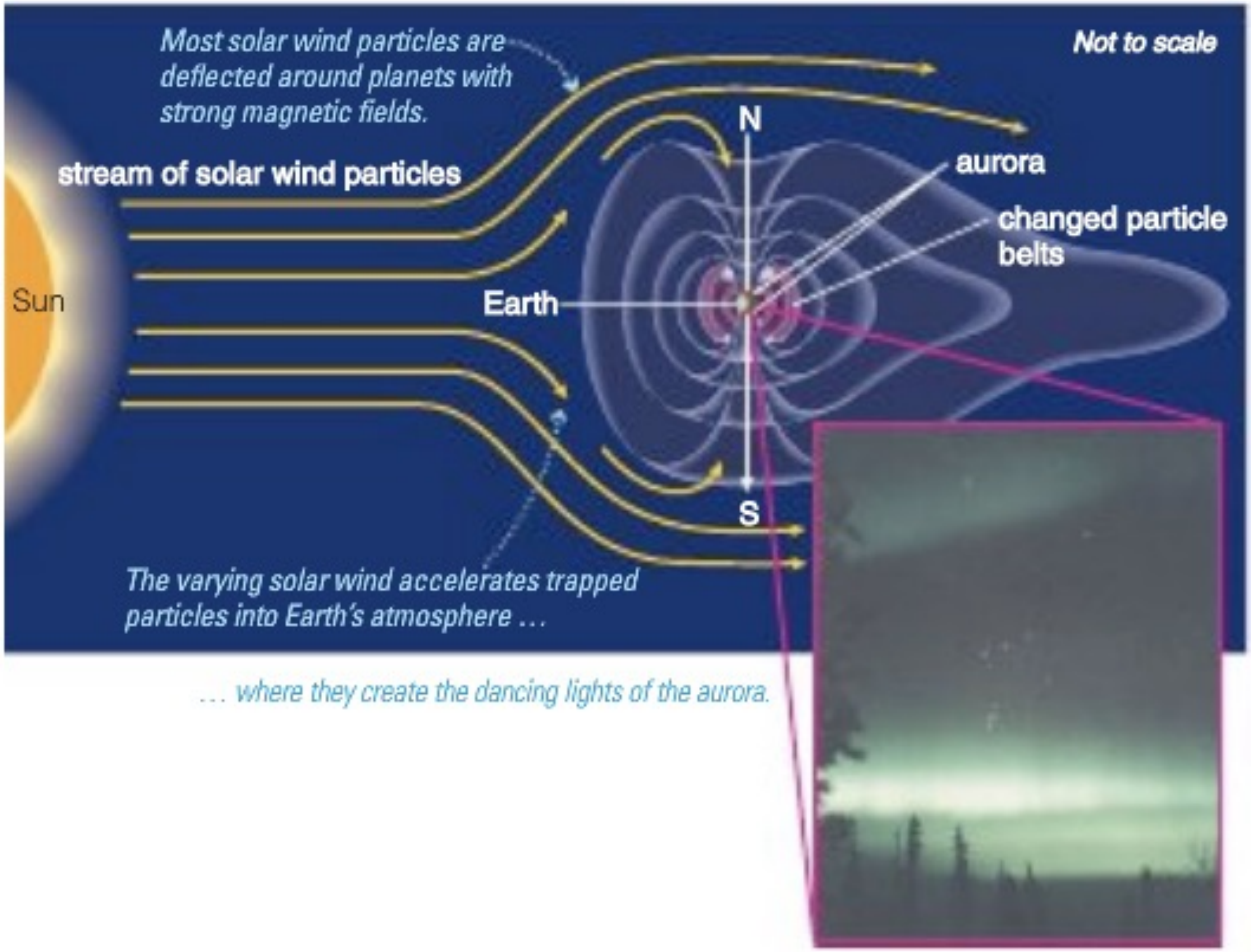


Figure 5.3. Page 78. *The Cosmic Perspective Fundamentals*. Publisher: Addison-Wesley. © 2010

AURORA BOREALIS

http://www.ptialaska.net/~hutch/aurora.html

THE FOUR GEOLOGICAL PROCESSES

Tectonics: the disruption of a planet’s surface by internal stresses.

Volcanism: the eruption of molten rock from a planet’s interior onto its surface.

Erosion: the wearing down or building up of geological features by wind, water, ice, and other planetary weather phenomena.

Impact Cratering: the creation of bowl-shaped impact craters by asteroids or comets striking a planet’s surface.

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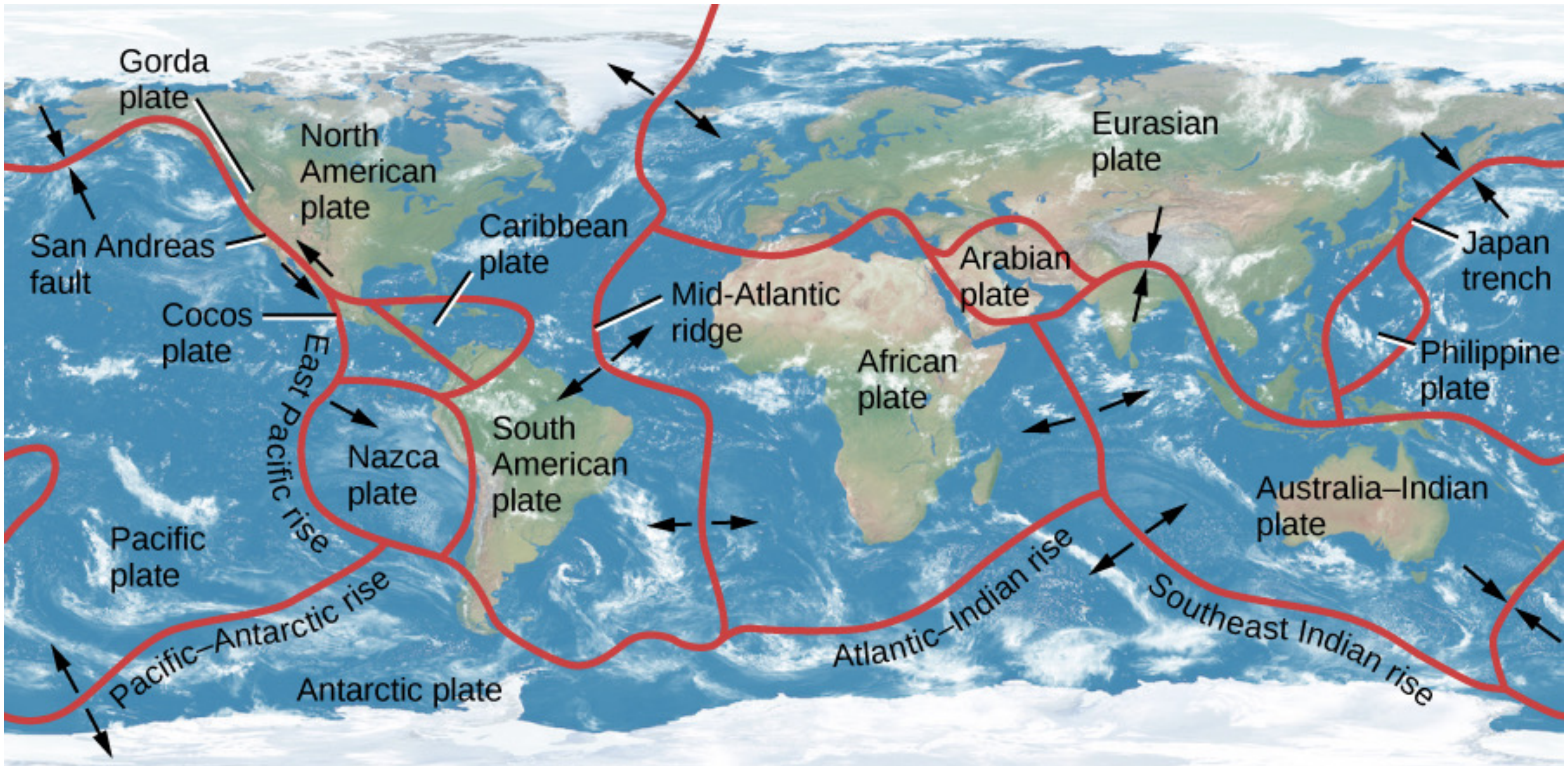
FIGURE 8.6

Formation of Igneous Rock as Liquid Lava Cools and Freezes. This is a lava flow from a basaltic eruption. Basaltic lava flows quickly and can move easily over distances of more than 20 kilometers. (credit: USGS)

FIGURE 8.7

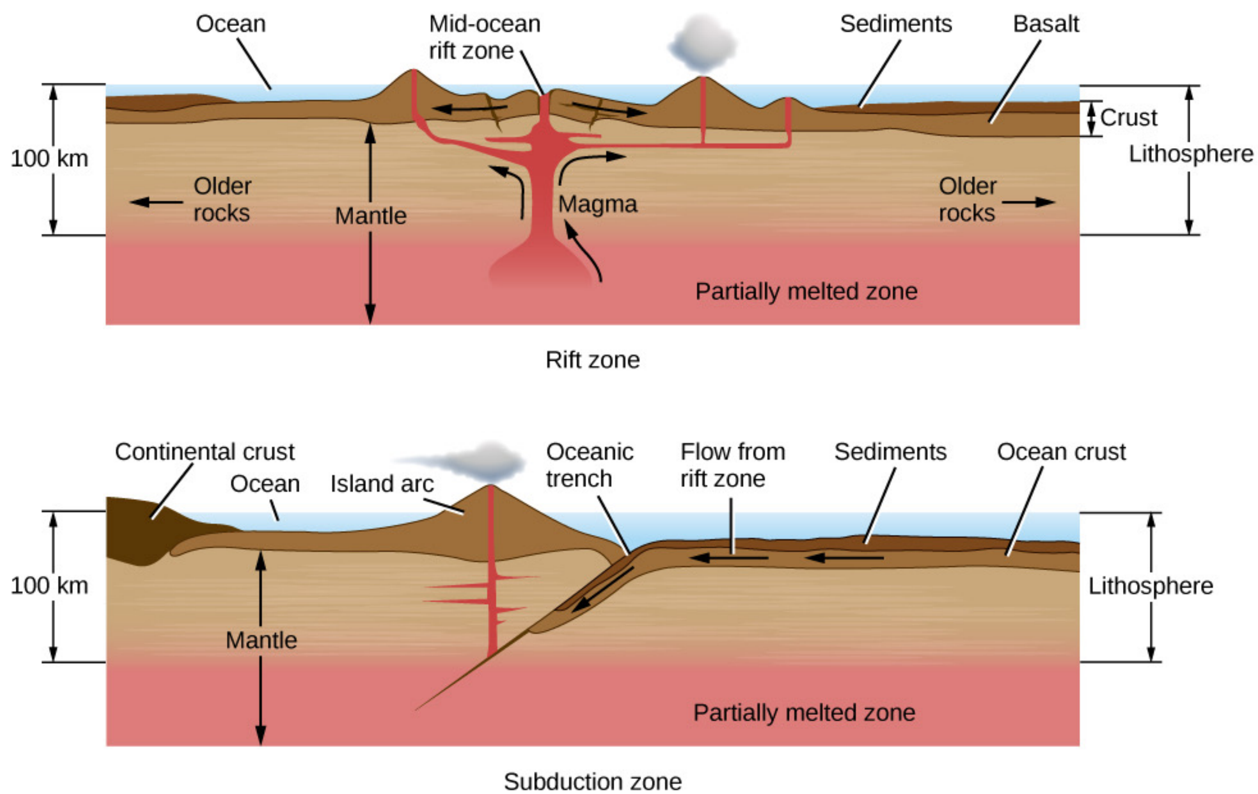


Earth's Continental Plates. This map shows the major plates into which the crust of Earth is divided. Arrows indicate the motion of the plates at average speeds of 4 to 5 centimeters per year, similar to the rate at which your hair grows.

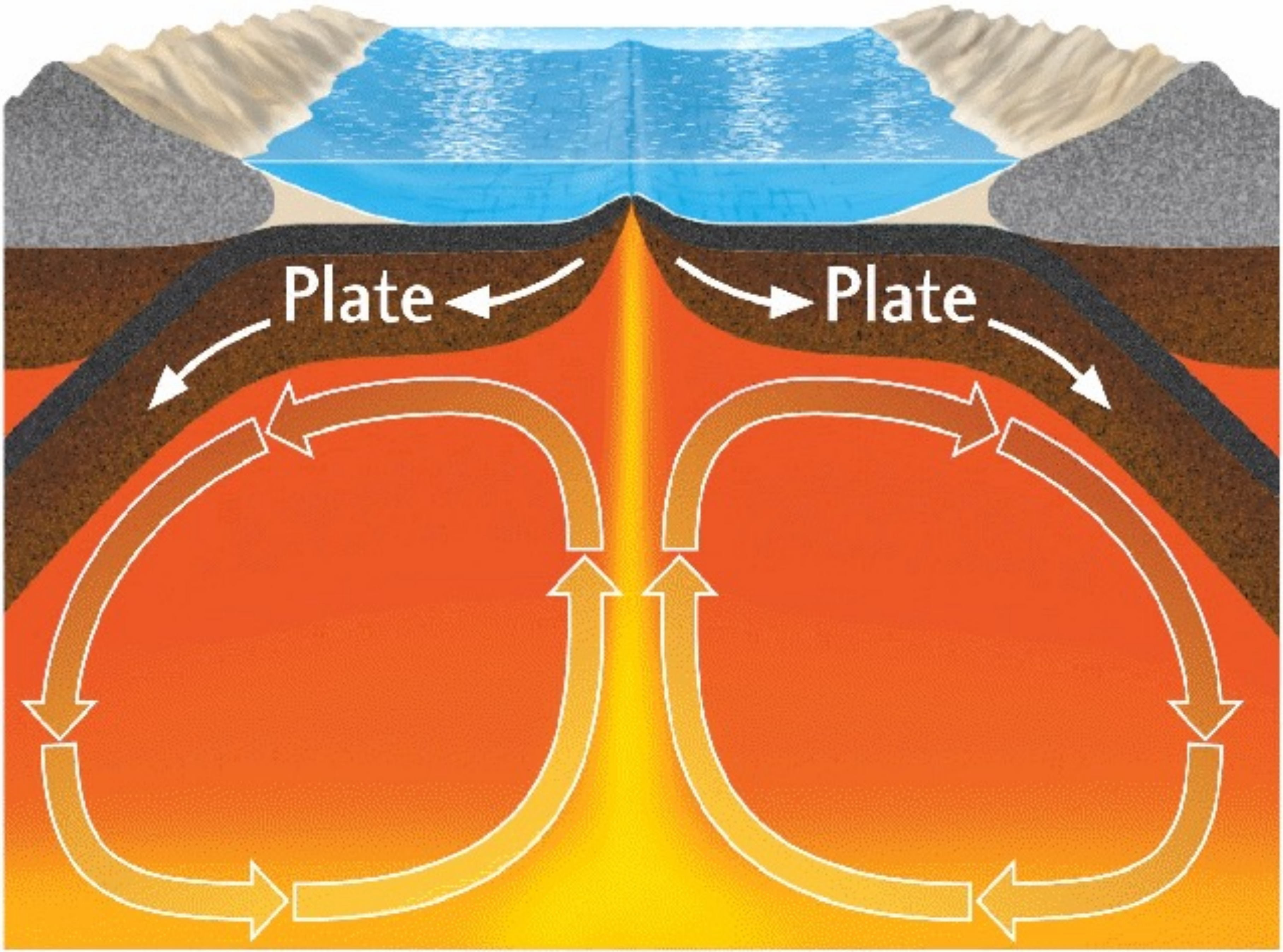
FIGURE 8.8

Alfred Wegener (1880–1930). Wegener proposed a scientific theory for the slow shifting of the continents.

FIGURE 8.9

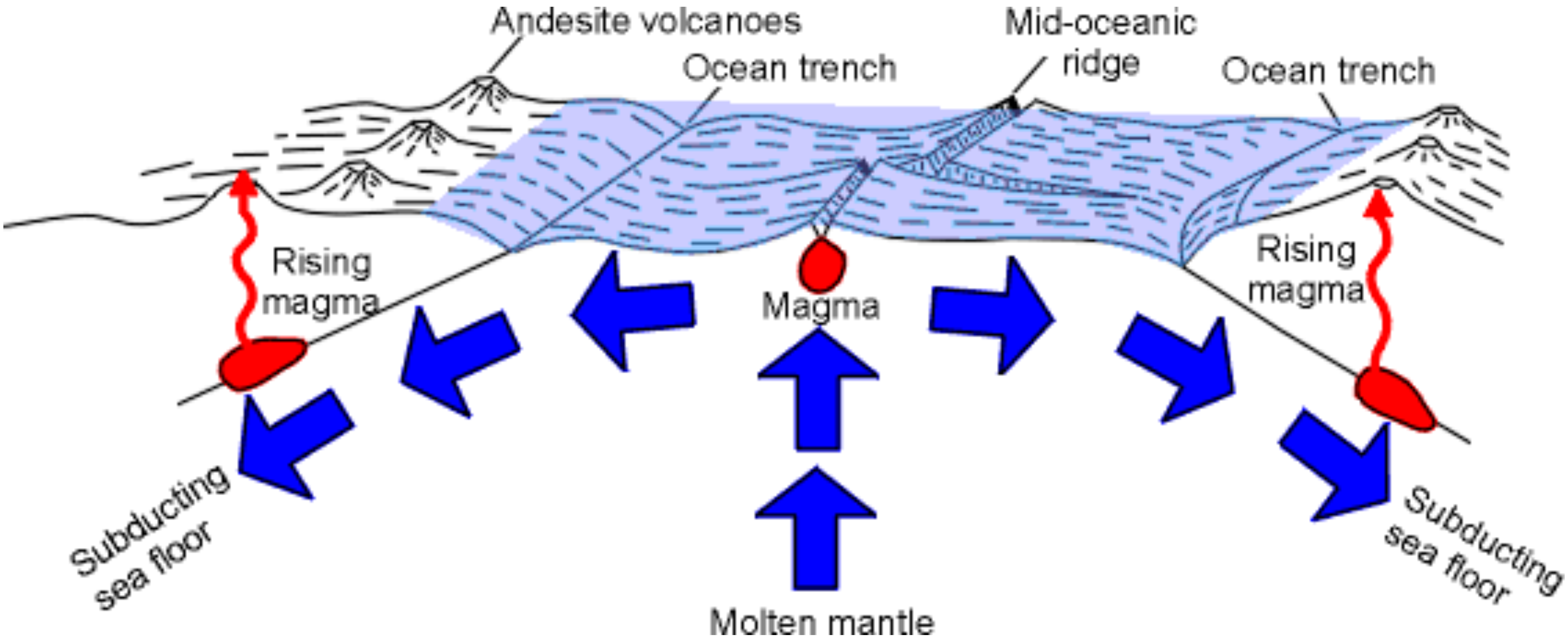


Rift Zone and Subduction Zone. Rift and subduction zones are the regions (mostly beneath the oceans) where new crust is formed and old crust is destroyed as part of the cycle of plate tectonics.



http://mail.colonial.net/~hkaiter/platetectonics.html

SUBDUCTION

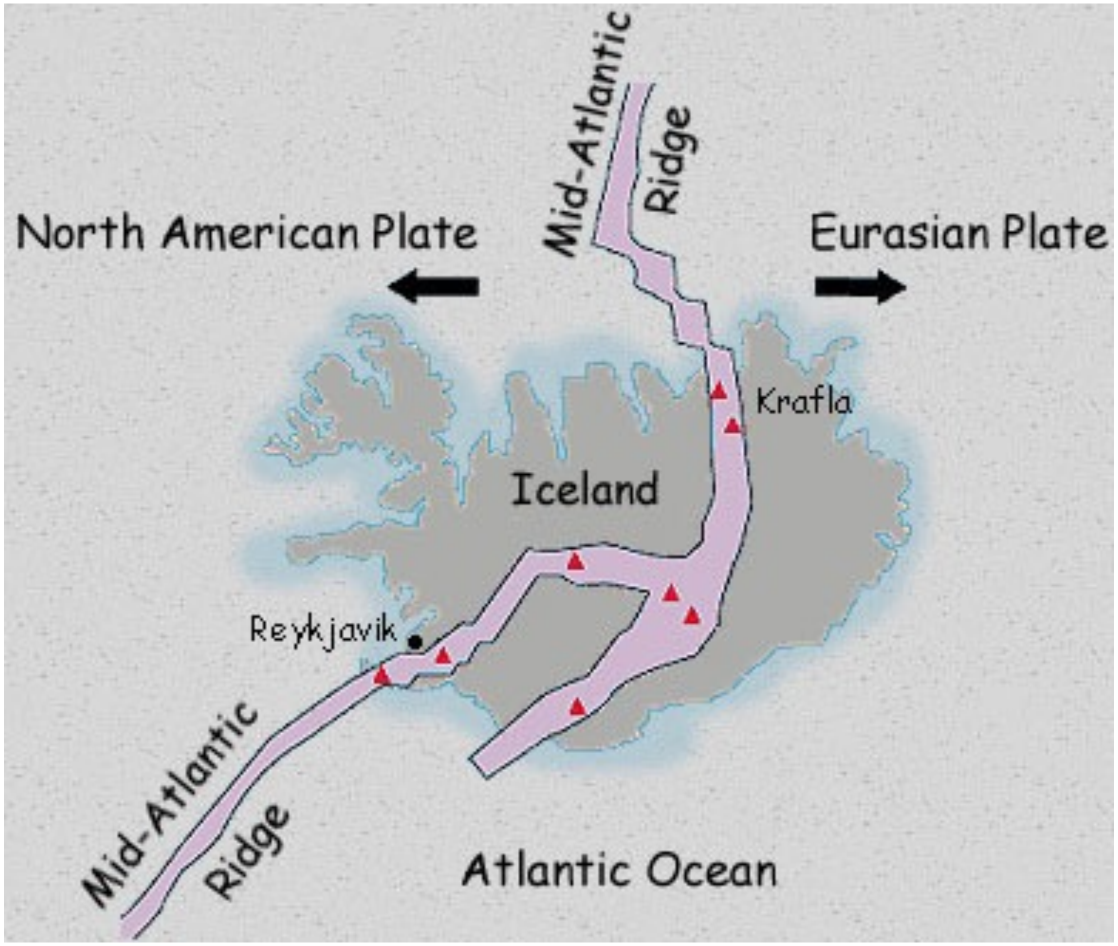


http://mail.colonial.net/~hkaiter/platetectonics.html

FIGURE 8.10

San Andreas Fault. We see part of a very active region in California where one crustal plate is sliding sideways with respect to the other. The fault is marked by the valley running up the right side of the photo. Major slippages along this fault can produce extremely destructive earthquakes. (credit: John Wiley)

ICELAND, “THE LAND OF FIRE AND ICE”



http://www.marinebio.net/marinescience/02ocean/mgtectonics.htm

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EROSION

Figure 5.7 | Erosion. The walls of the Grand Canyon consist of layers of sedimentary rock built up by erosion over hundreds of millions of years. These walls are exposed because the Colorado River has carved the deep canyon over the past few million years.

FIGURE 8.11

Mountains on Earth. The Torres del Paine are a young region of Earth’s crust where sharp mountain peaks are being sculpted by glaciers. We owe the beauty of our young, steep mountains to the erosion by ice and water. (credit: David Morrison)

FIGURE 8.12

Structure of Earth's Atmosphere.
Height increases up the left side of the diagram, and the names of the different atmospheric layers are shown at the right. In the upper ionosphere, ultraviolet radiation from the Sun can strip electrons from their atoms, leaving the atmosphere ionized. The curving red line shows the temperature (see the scale on the *x*-axis).

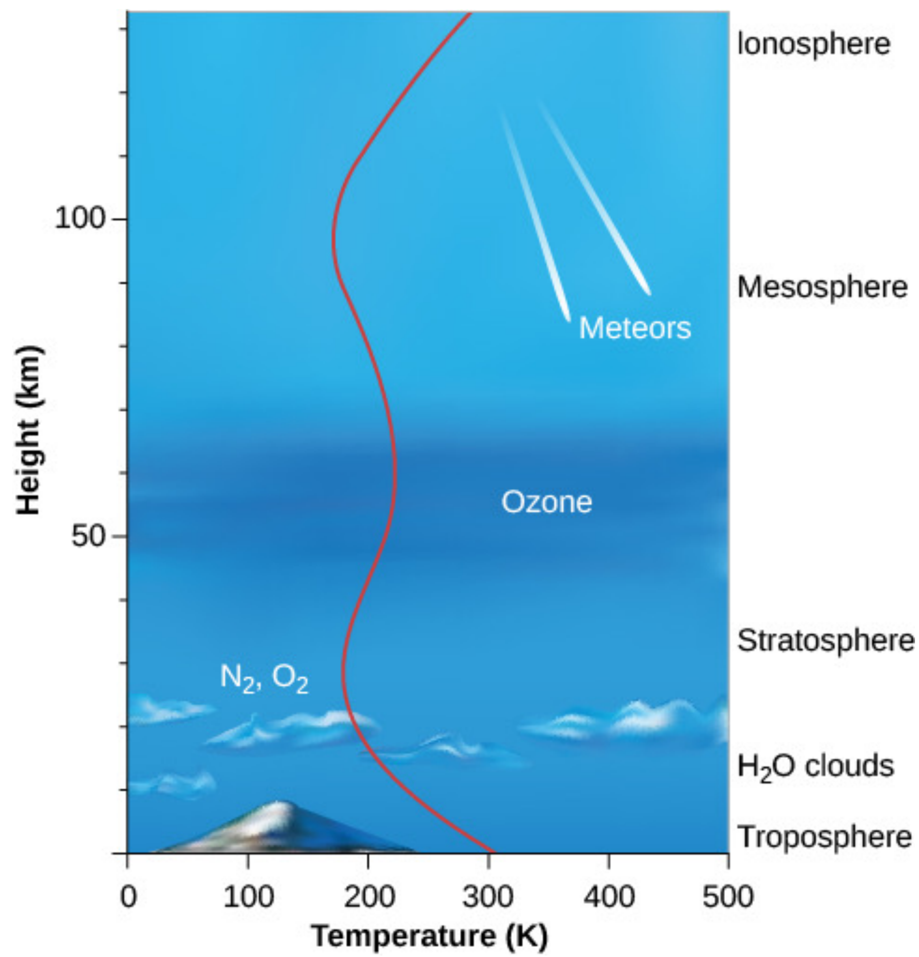
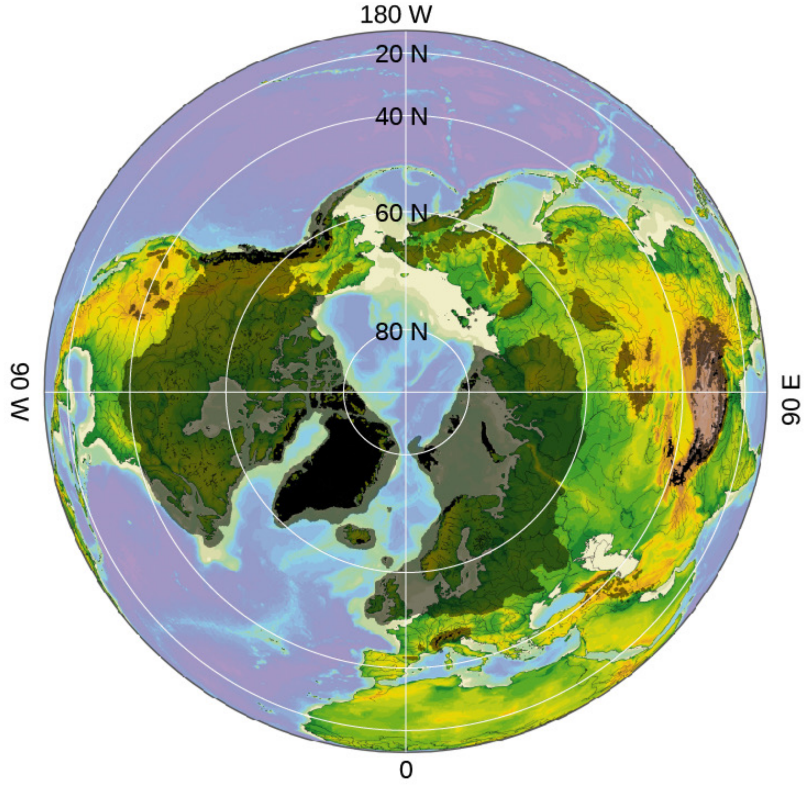


FIGURE 8.13

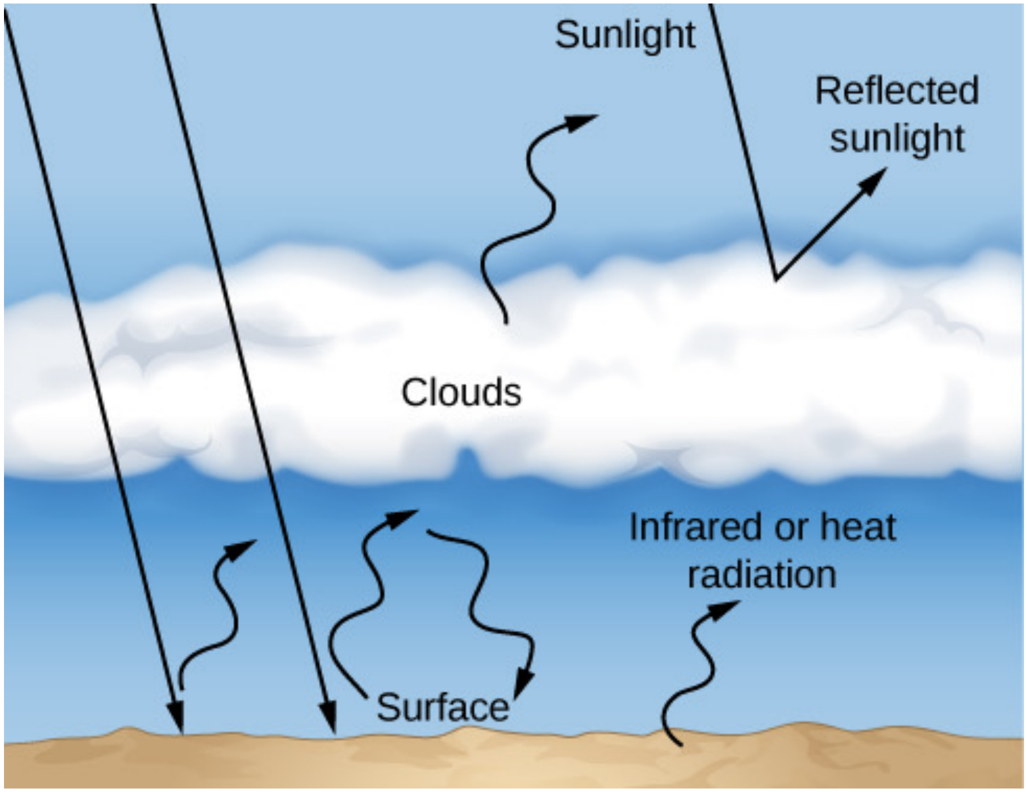
Storm from Space. This satellite image shows Hurricane Irene in 2011, shortly before the storm hit land in New York City. The combination of Earth’s tilted axis of rotation, moderately rapid rotation, and oceans of liquid water can lead to violent weather on our planet. (credit: NASA/NOAA GOES Project)

FIGURE 8.14



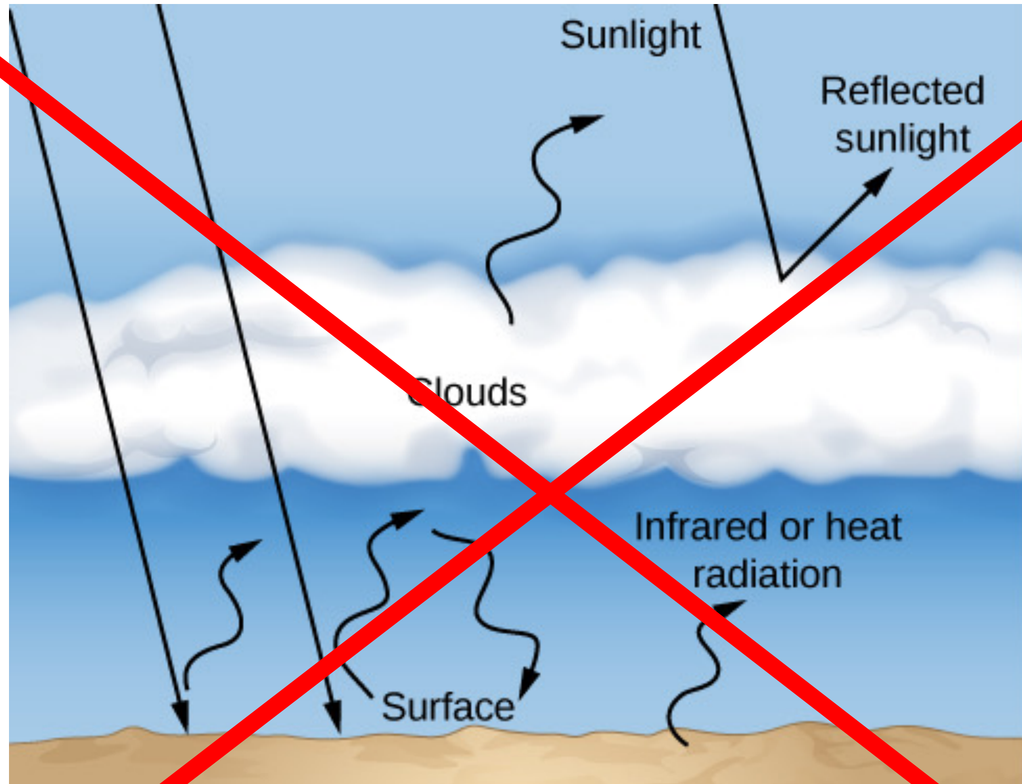
Ice Age. This computer-generated image shows the frozen areas of the Northern Hemisphere during past ice ages from the vantage point of looking down on the North Pole. The area in black indicates the most recent glaciation (coverage by glaciers), and the area in gray shows the maximum level of glaciation ever reached. (credit: modification of work by Hannes Grobe/AWI)

FIGURE 8.17



How the Greenhouse Effect Works. Sunlight that penetrates to Earth's lower atmosphere and surface is reradiated as infrared or heat radiation, which is trapped by greenhouse gases such as water vapor, methane, and CO_2 in the atmosphere. The result is a higher surface temperature for our planet.

FIGURE 8.17



How the Greenhouse Effect Works. Sunlight that penetrates to Earth's lower atmosphere and surface is reradiated as infrared or heat radiation, which is trapped by greenhouse gases such as water vapor, methane, and CO_2 in the atmosphere. The result is a higher surface temperature for our planet.

How the Greenhouse Effect Works:

1). It’s NOT a Greenhouse (which acts to suppress convection)

2). The Earth’s surface receives energy from two sources: The Sun and the Atmosphere.

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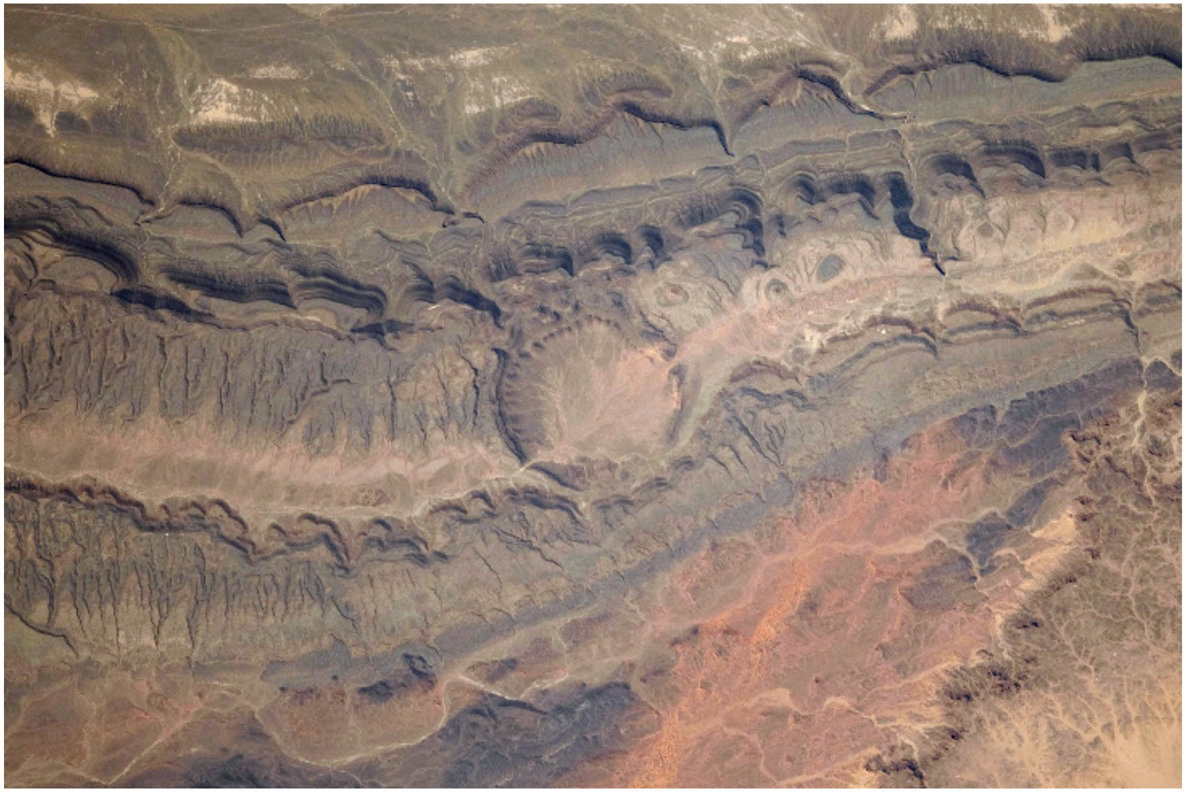
FIGURE 8.19



Ouarkziz Impact Crater. Located in Algeria, this crater (the round feature in the center) is the result of a meteor impact during the Cretaceous period. Although the crater has experienced heavy erosion, this image from the International Space Station shows the circular pattern resulting from impact. (credit: modification of work by NASA)

FIGURE 8.21

Meteor Crater in Arizona. Here we see a 50,000-year-old impact crater made by the collision of a 40-meter lump of iron with our planet. Although impact craters are common on less active bodies such as the Moon, this is one of the very few well-preserved craters on Earth. (modification of work by D. Roddy/USGS)

FIGURE 9.18

Meteor Crater. This aerial photo of Meteor Crater in Arizona shows the simple form of a meteorite impact crater. The crater’s rim diameter is about 1.2 kilometers. (credit: Shane Torgerson)

FIGURE 8.20

Aftermath of the Tunguska Explosion. This photograph, taken 21 years after the blast, shows a part of the forest that was destroyed by the 5-megaton explosion, resulting when a stony projectile about the size of a small office building (40 meters in diameter) collided with our planet. (credit: modification of work by Leonid Kulik)

FIGURE 8.22

Site of the Chicxulub Crater. This map shows the location of the impact crater created 65 million years ago on Mexico's Yucatán peninsula. The crater is now buried under more than 500 meters of sediment. (credit: modification of work by "Carport"/Wikimedia)

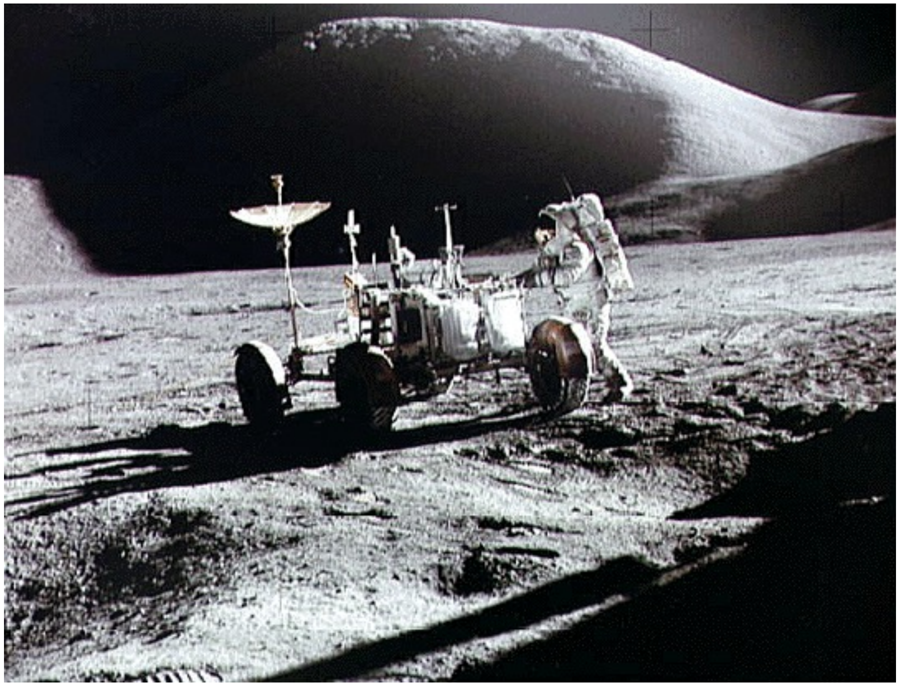
ASTRONOMY

Chapter 8 EARTH AS A PLANET
Chapter 9 CRATERED WORLDS

THE SURFACE OF THE MOON

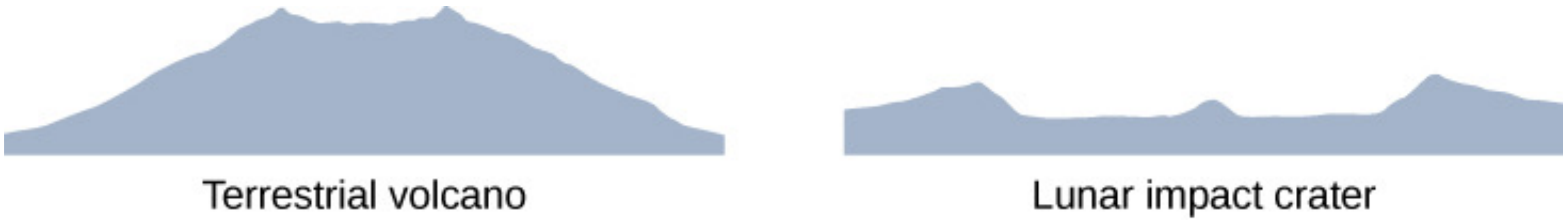
The Surface of the Moon is dominated by:

- craters,
- highlands (mountainous areas), and
- maria (low-lying lava-filled depressions).



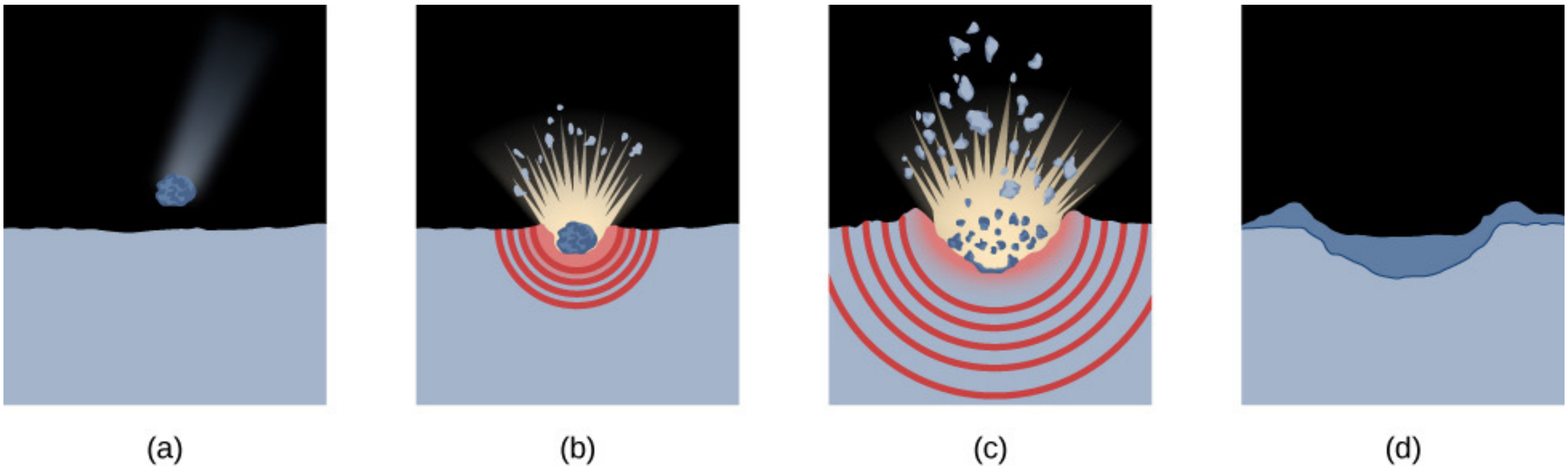
http://starchild.gsfc.nasa.gov/docs/StarChild/space_level2/apollo15_rover.html

FIGURE 9.13



Volcanic and Impact Craters. Profiles of a typical terrestrial volcanic crater and a typical lunar impact crater are quite different.

FIGURE 9.14



Stages in the Formation of an Impact Crater.

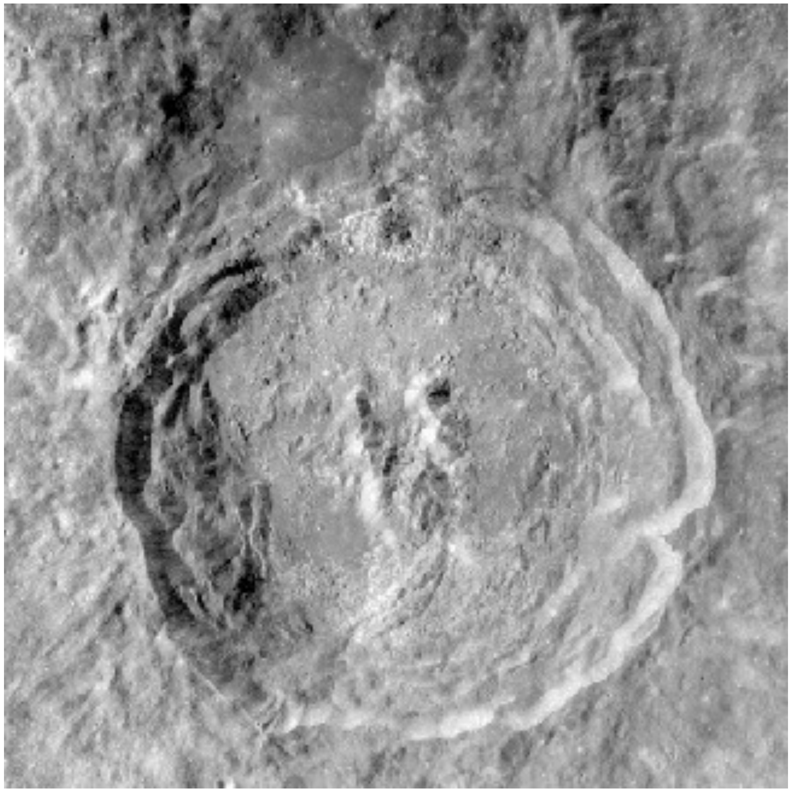
(a) The impact occurs.

(b) The projectile vaporizes and a shock wave spreads through the lunar rock.

(c) Ejecta are thrown out of the crater.

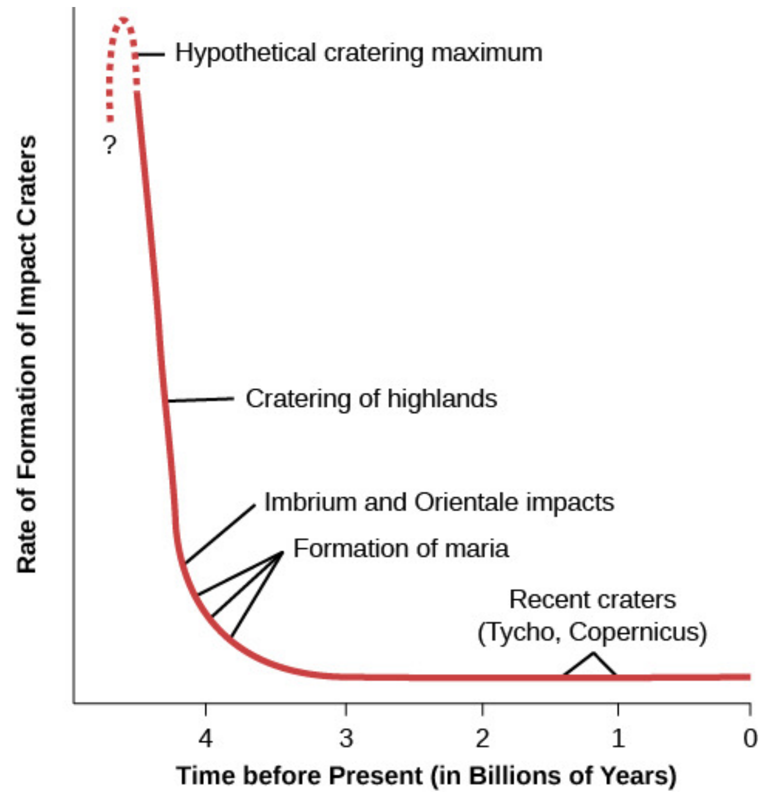
(d) Most of the ejected material falls back to fill the crater, forming an ejecta blanket.

FIGURE 9.15



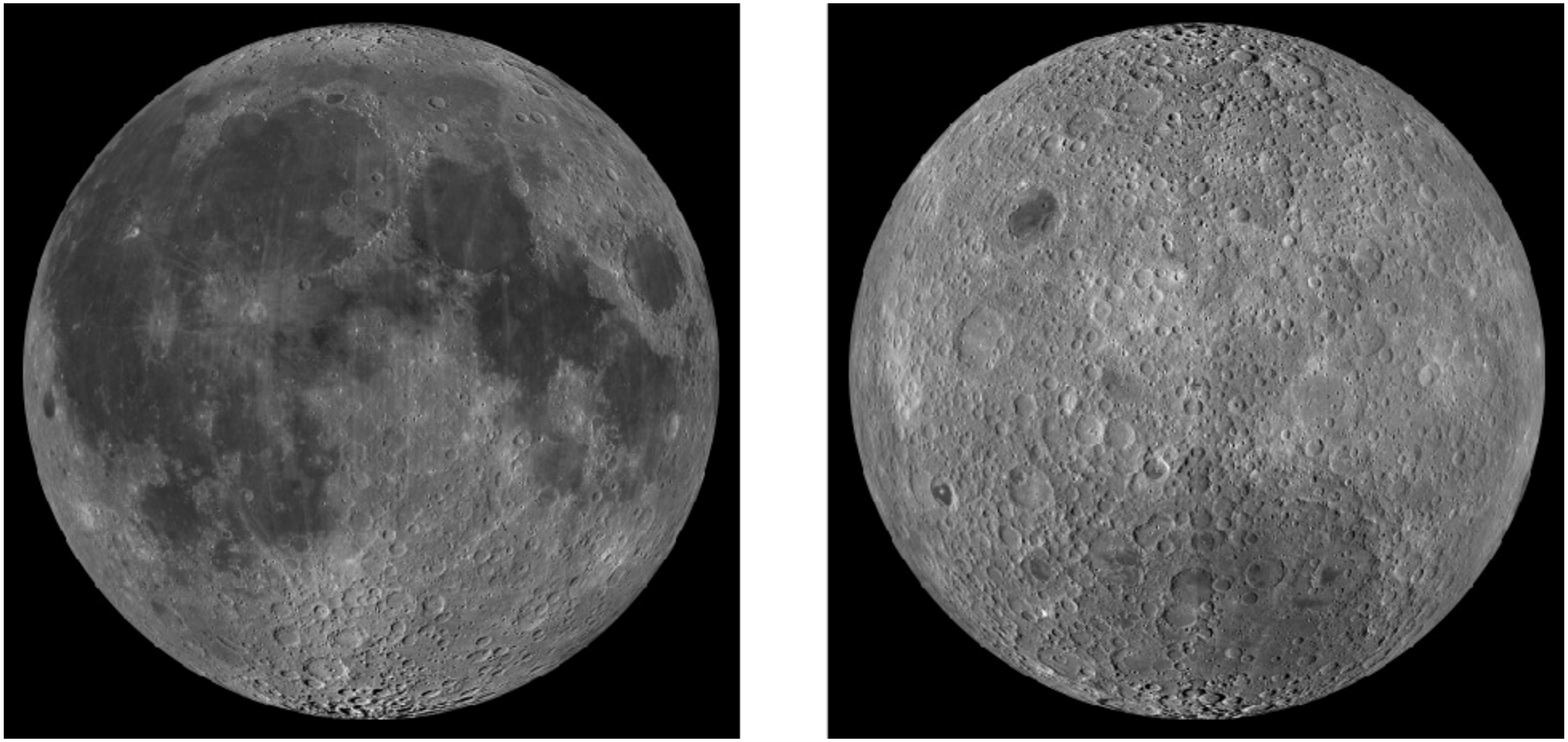
Typical Impact Crater. King Crater on the far side of the Moon, a fairly recent lunar crater 75 kilometers in diameter, shows most of the features associated with large impact structures. (credit: NASA/JSC/Arizona State University)

FIGURE 9.19



Cratering Rates over Time. The number of craters being made on the Moon's surface has varied with time over the past 4.3 billion years.

FIGURE 9.2



Two Sides of the Moon. The left image shows part of the hemisphere that faces Earth; several dark maria are visible. The right image shows part of the hemisphere that faces away from Earth; it is dominated by highlands. The resolution of this image is several kilometers, similar to that of high-powered binoculars or a small telescope. (credit: modification of work by NASA/GSFC/Arizona State University)

FIGURE 9.16

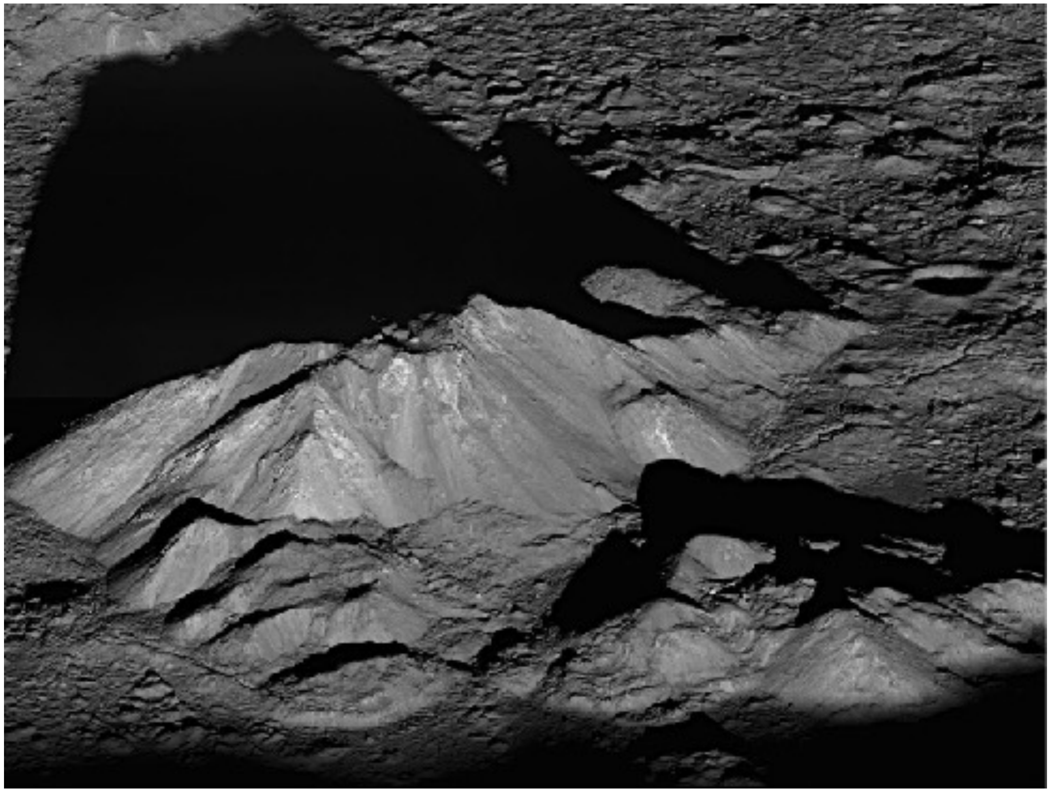
(a) (b)

Appearance of the Moon at Different Phases.

(a) Illumination from the side brings craters and other topographic features into sharp relief, as seen on the far left side.

(b) At full phase, there are no shadows, and it is more difficult to see such features. However, the flat lighting at full phase brings out some surface features, such as the bright rays of ejecta that stretch out from a few large young craters. (credit: modification of work by Luc Viatour)

FIGURE 9.6

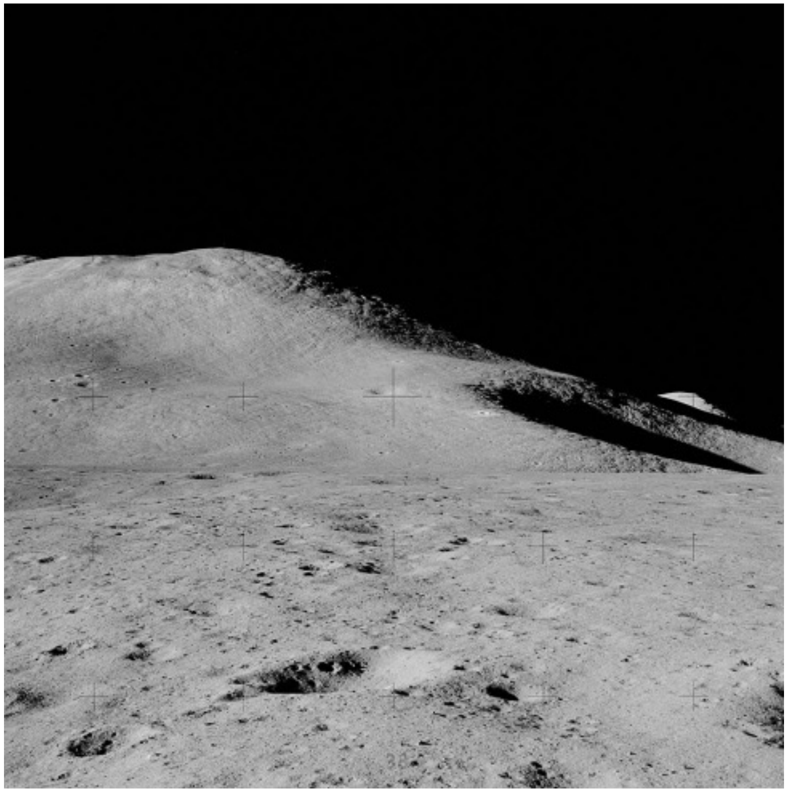


Sunrise on the Central Mountain Peaks of Tycho Crater, as Imaged by the NASA Lunar Reconnaissance Orbiter. Tycho, about 82 kilometers in diameter, is one of the youngest of the very large lunar craters. The central mountain rises 12 kilometers above the crater floor. (credit: modification of work by NASA/Goddard/Arizona State University)

FIGURE 9.7

Lunar Highlands. The old, heavily cratered lunar highlands make up 83% of the Moon’s surface. (credit: Apollo 11 Crew, NASA)

FIGURE 9.8



Lunar Mountain. This photo of Mt. Hadley on the edge of Mare Imbrium was taken by Dave Scott, one of the Apollo 15 astronauts. Note the smooth contours of the lunar mountains, which have not been sculpted by water or ice. (credit: NASA/Apollo Lunar Surface Journal)

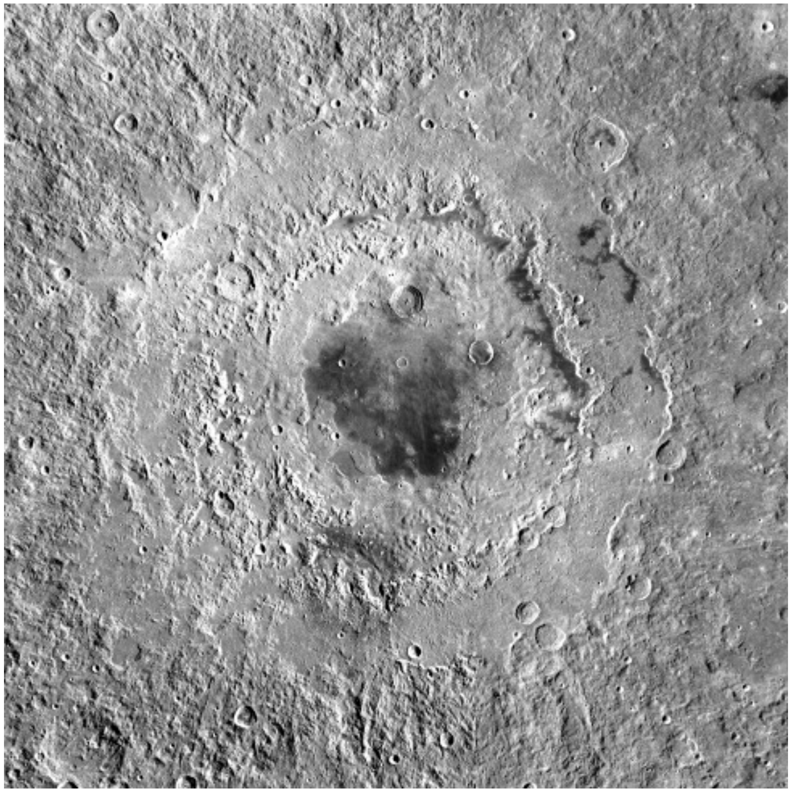
FIGURE 9.9

Lunar Maria. About 17% of the Moon's surface consists of the maria—flat plains of basaltic lava. This view of Mare Imbrium also shows numerous secondary craters and evidence of material ejected from the large crater Copernicus on the upper horizon. Copernicus is an impact crater almost 100 kilometers in diameter that was formed long after the lava in Imbrium had already been deposited. (credit: NASA, Apollo 17)

FIGURE 9.10

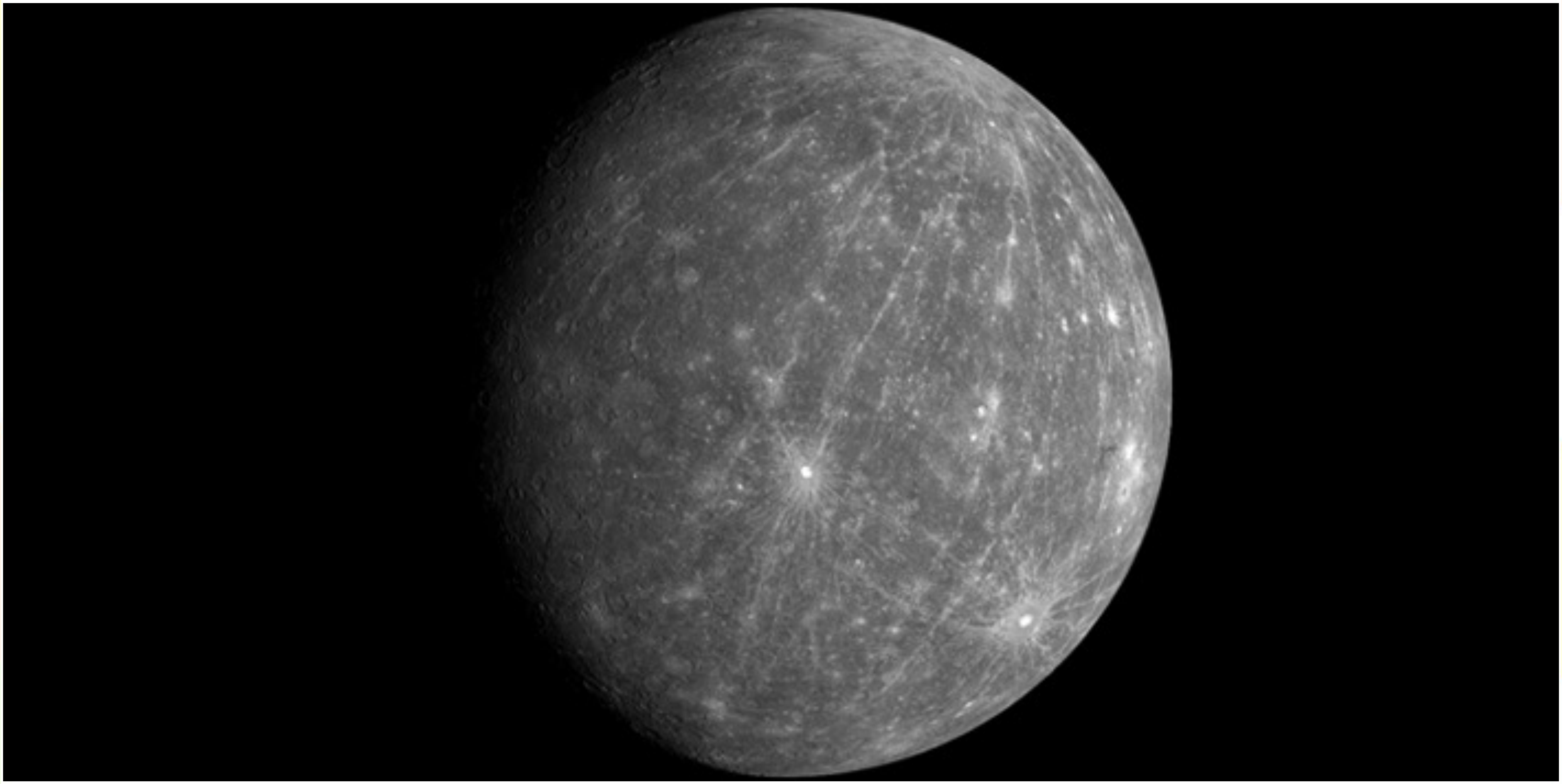
Rock from a Lunar Mare. In this sample of basalt from the mare surface, you can see the holes left by gas bubbles, which are characteristic of rock formed from lava. All lunar rocks are chemically distinct from terrestrial rocks, a fact that has allowed scientists to identify a few lunar samples among the thousands of meteorites that reach Earth. (credit: modification of work by NASA)

FIGURE 9.11



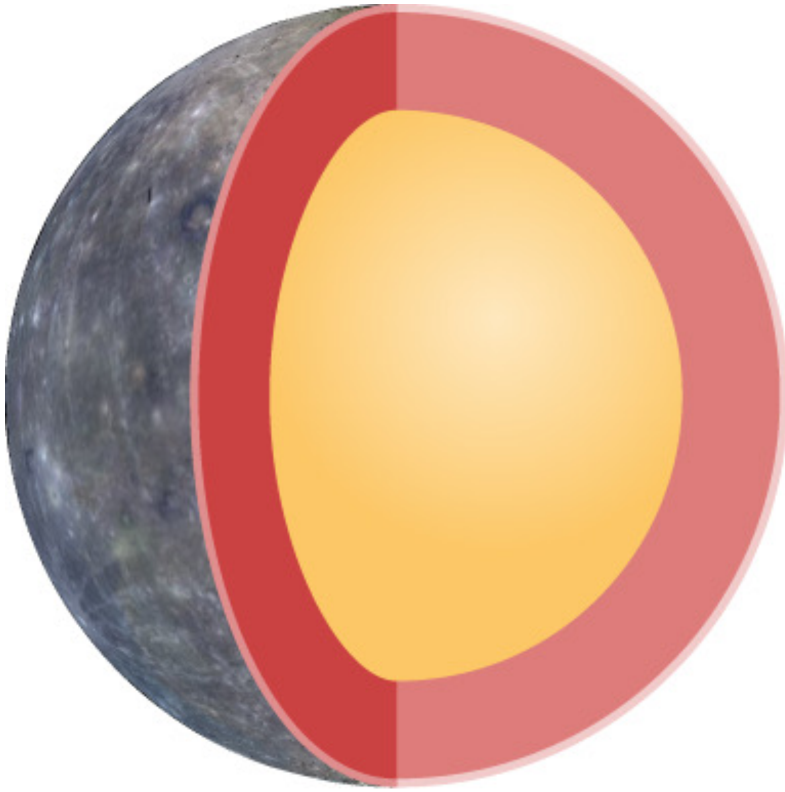
Mare Orientale. The youngest of the large lunar impact basins is Orientale, formed 3.8 billion years ago. Its outer ring is about 1000 kilometers in diameter, roughly the distance between New York City and Detroit, Michigan. Unlike most of the other basins, Orientale has not been completely filled in with lava flows, so it retains its striking “bull’s-eye” appearance. It is located on the edge of the Moon as seen from Earth. (credit: NASA)

MESSENGER SPACECRAFT IMAGE OF MERCURY



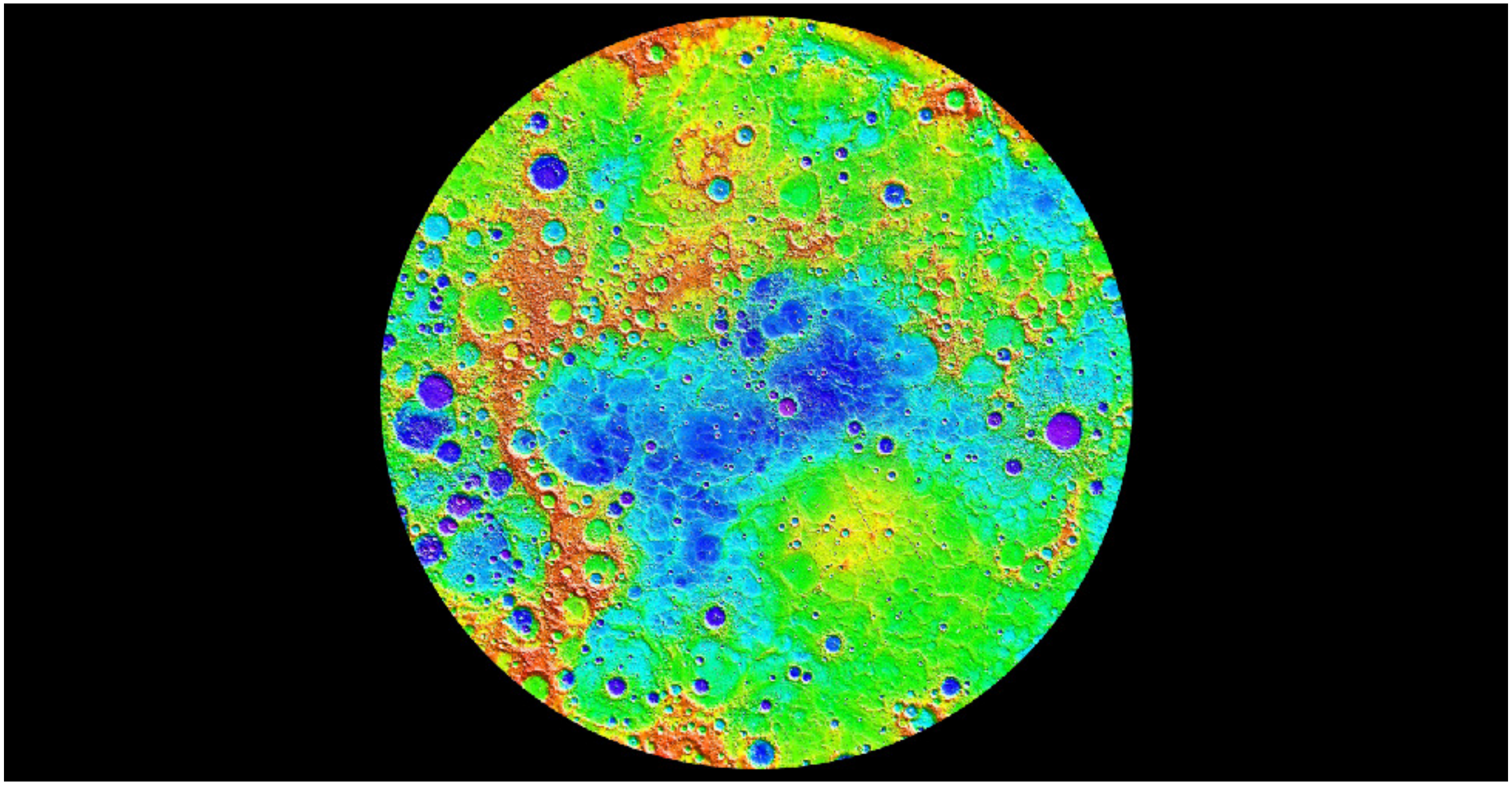
http://solarsystem.nasa.gov/planets/profile.cfm?Object=Mercury

FIGURE 9.20



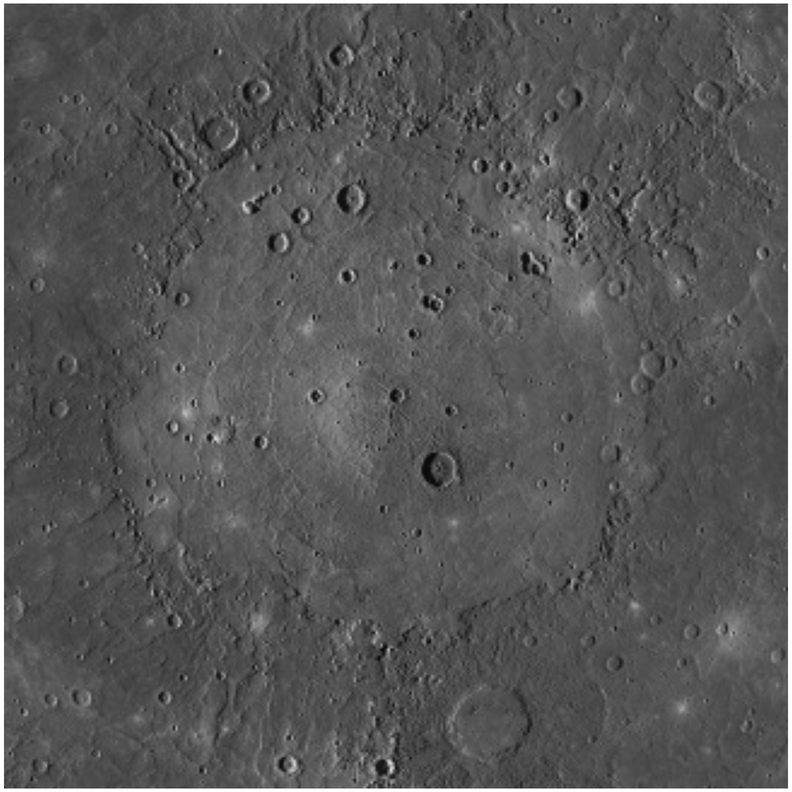
Mercury's Internal Structure. The interior of Mercury is dominated by a metallic core about the same size as our Moon.

FIGURE 9.22



Mercury's Topography. The topography of Mercury's northern hemisphere is mapped in great detail from MESSENGER data. The lowest regions are shown in purple and blue, and the highest regions are shown in red. The difference in elevation between the lowest and highest regions shown here is roughly 10 kilometers. The permanently shadowed low-lying craters near the north pole contain radar-bright water ice. (credit: modification of work by NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington)

FIGURE 9.23



Caloris Basin. This partially flooded impact basin is the largest known structural feature on Mercury. The smooth plains in the interior of the basin have an area of almost two million square kilometers. Compare this photo with **Figure 9.11**, the Orientale Basin on the Moon. (credit: NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington)

FIGURE 9.24

Discovery Scarp on Mercury. This long cliff, nearly 1 kilometer high and more than 100 kilometers long, cuts across several craters. Astronomers conclude that the compression that made “wrinkles” like this in the surface must have taken place after the craters were formed. (credit: modification of work by NASA/JPL/Northwestern University)