Planetary “Geology”

Earth 9th Edition - Chapter 24

Planetary Geology: summary in haiku form
Can it be geo-?
When there's only one planet
qualified as "Earth?"

Key Concepts
- The planets of our Solar System.
- Earth's moon.
- The terrestrial (inner) planets.
- The Jovian (outer) planets.
- Other components of our Solar System: Asteroids, comets, meteoroids, and the dwarf planet Pluto.

Overview of the solar system
- Solar system includes
  - Sun
  - Eight planets and their satellites
  - Dwarf planets
  - Asteroids
  - Comets
  - Meteoroids

The solar system
- A planet's orbit lies in an orbital plane
  - Similar to a flat sheet of paper
  - The orbital planes of the planets are inclined
    - Planes of seven planets lie within 3° of the Sun's equator
    - Mercury's is inclined 7°
    - Pluto's is inclined 17°

Overview of the solar system
- Two groups of planets occur in the solar system
  - Terrestrial (Earth-like) planets
    - Mercury through Mars
    - Small, dense, rocky
    - Low escape velocities
  - Jovian (Jupiter-like) planets
    - Jupiter through Neptune
    - Large, low density, gaseous
    - Massive
    - Thick atmospheres composed of hydrogen, helium, methane, and ammonia
    - High escape velocities
  - Pluto not included in either group

The planets drawn to scale
Overview of the solar system
- Planets are composed of
• Gases
  • Hydrogen
  • Helium
• Rocks
  • Silicate minerals
  • Metallic iron

11 **Overview of the solar system**
  ★ Planets are composed of
  • Ices
    • Ammonia (NH₃)
    • Methane (CH₄)
    • Carbon dioxide (CO₂)
    • Water (H₂O)

12 **Evolution of the planets**
  ★ Nebular hypothesis
    • Planets formed about 5 billion years ago
    • Solar system condensed from a gaseous nebula
  ★ As the planets formed, the materials that compose them separated
    • Dense metallic elements (iron and nickel) sank toward their centers

13 **Evolution of the planets**
  ★ As the planets formed, the materials that compose them separated
    • Lighter elements (silicate minerals, oxygen, hydrogen) migrated toward their surfaces
    • Process called chemical differentiation

14 **Evolution of the planets**
  ★ Due to their surface gravities, Venus and Earth retained atmospheric gases
  ★ Due to frigid temperatures, the Jovian planets contain a high percentage of ices

15 **Earth's Moon**
  ★ General characteristics
    • Diameter of 3475 kilometers (2150 miles) is unusually large compared to its parent planet
    • Density
      • 3.3 times that of water
      • Comparable to Earth's crustal rocks
      • Perhaps the Moon has a small iron core

16 **Earth's Moon**
  ★ General characteristics
    • Gravitational attraction is one-sixth of Earth's
    • No atmosphere
    • Tectonics no longer active
    • Surface is bombarded by micrometeorites from space which gradually make the landscape smooth

17 **Figure 24.3**

18 **Lunar Surface Features**

19 **Earth's Moon**
  ★ Lunar surface
    • Two types of terrain
      • Maria (singular, mare), Latin for "sea"
      • Dark regions
      • Fairly smooth lowlands
Originated from asteroid impacts and lava flooding the surface

Formation of lunar maria, stage one:
Formation of lunar maria
Earth's Moon

Lunar surface
Two types of terrain
Highlands
Bright, densely cratered regions
Make up most of the Moon
Make up all of the “back” side of the Moon
Older than maria

Craters
Most obvious features of the lunar surface

Earth's Moon
Lunar surface
Craters
Ejecta
Occasional rays (associated with younger craters)

Anatomy of an Impact Crater:

Earth's Moon

Lunar surface
Lunar regolith
Covers all lunar terrains
Gray, unconsolidated debris
Composed of
Igneous rocks
Breccia
Glass beads
Fine lunar dust

Harrison Schmitt
Footprint in the Lunar “soil”

Earth's Moon
Lunar history
Hypothesis suggests that a giant asteroid collided with Earth to produce the Moon
Older areas have a higher density
Younger areas are still smooth

Figure 24.9A,B
Figure 24.9C,D
Figure 24.9E
Planets: A brief tour
Mercury
Innermost planet
• Second smallest planet
• No atmosphere
• Cratered highlands
• Vast, smooth terrains
• Very dense
• Revolves quickly, rotates slowly

**Photo mosaic of Mercury**

**Planets: A brief tour**

**Venus**
• Second to the Moon in brilliance
• Similar to Earth in
  ◆ Size
  ◆ Density
  ◆ Location in the solar system
• Shrouded in thick clouds
  ◆ Atmosphere is 97% carbon dioxide
  ◆ Surface atmospheric pressure is 90 times that of Earth’s

**Planets: A brief tour**

**Venus**
• Surface
  ◆ Mapped by radar
  ◆ Features
    ◆ 80% of surface is subdued plains that are mantled by volcanic flows
    ◆ Low density of impact craters
    ◆ Tectonic deformation must have been active during the recent geologic past
    ◆ Thousands of volcanic structures

**Computer generated view of Venus**

**Planets: A brief tour**

**Mars**
• Called the "Red Planet"
• Atmosphere
  ◆ 1% as dense as Earth's
  ◆ Primarily carbon dioxide
  ◆ Cold polar temperatures (-193°F)
  ◆ Polar caps of water ice, covered by a thin layer of frozen carbon dioxide
  ◆ Extensive dust storms with winds up to 270 kilometers (170 miles) per hour

**Planets: A brief tour**

**Mars**
• Surface
  ◆ Numerous large volcanoes - largest is Mons Olympus
  ◆ Less-abundant impact craters
  ◆ Tectonically dead
Several canyons
• Some larger than Earth’s Grand Canyon
• Valles Marineras - the largest canyon

**Mons Olympus, an inactive shield volcano on Mars**

**Pathfinder: first geologist on Mars**

**The Valles Marineris canyon system on Mars**

**Crater wall, water gullies**

**Streamlined islands in Ares Valles**

**Terraces and stream channel**

**Patterned ground: permafrost?**

**Planets: A brief tour**

**Mars**
• Surface
  • "Stream drainage" patterns
    • Found in some valleys
    • No bodies of surface water on the planet
  • Possible origins
    • Past rainfall
    • Surface material collapses as the subsurface ice melts

**Planets: A brief tour**

**Jupiter**
• Largest planet
• Very massive
  • 2.5 times more massive than combined mass of the planets, satellites, and asteroids
  • If it had been ten times larger, it would have been a small star
• Rapid rotation
• Slightly less than 10 hours

**Artist's view of Jupiter with the Great Red Spot visible**

**Atmospheric structure**

**Planets: A brief tour**

**Jupiter**
• Banded appearance
  • Multicolored
  • Bands are aligned parallel to Jupiter's equator
  • Generated by wind systems
  • Rapid rotation
  • Slightly less than 10 hours
• Great Red Spot
  • In planet's southern hemisphere
  • Counterclockwise rotating cyclonic storm

**Planets: A brief tour**

**Jupiter**
• Structure
  • Surface thought to be a gigantic ocean of liquid hydrogen
  • Halfway into the interior, pressure causes liquid hydrogen to turn into liquid metallic hydrogen
  • Rocky and metallic material probably exists in a central core
Planets: A brief tour

Jupiter
- At least 28 moons
  - Four largest moons
    - Discovered by Galileo
    - Each has its own character
      - Callisto - outermost Galilean moon
      - Europa - smallest Galilean moon
      - Ganymede - largest Jovian satellite
      - Io - innermost Galilean moon and is also volcanically active

Saturn
- Similar to Jupiter in its:
  - Atmosphere
  - Composition
  - Internal structure
- Rings
  - Most prominent feature
  - Discovered by Galileo in 1610
  - Complex

Planets: A brief tour

Saturn
- Composed of small particles (moonlets) that orbit the planet
  - Most rings fall into one of two categories based on particle density
  - Thought to be debris ejected from moons
  - Origin is still being debated

The ring system of Saturn

Saturn & moons

Uranus
- Uranus and Neptune are nearly twins
- Rotates "on its side"
- Rings
- Large moons have varied terrains

Neptune
- Dynamic atmosphere
One of the windiest places in the solar system
Great Dark Spot
White cirrus-like clouds above the main cloud deck
Eight satellites
Triton – largest Neptune moon
Orbit is opposite the direction that all the planet's travel
Lowest surface temperature in the solar system

Planets: A brief tour

Neptune
• Triton – largest Neptune moon
  • Atmosphere of mostly nitrogen with a little methane
  • Volcanic-like activity
  • Composed largely of water ice, covered with layers of solid nitrogen and methane

A Demoted Former Planet:

Pluto
• Not visible with the unaided eye
• Discovered in 1930
• Highly elongated orbit causes it to occasionally travel inside the orbit of Neptune, where it resided from 1979 thru February 1999
• Moon (Charon) discovered in 1978
• Average temperature is -210ºC
• International Astronomical Union added new class of dwarf planets in 2006

Minor members of the solar system

Asteroids
• Most lie between Mars and Jupiter
• Small bodies – largest (Ceres) is about 620 miles in diameter
• Some have very eccentric orbits
• Many of the recent impacts on the Moon and Earth were collisions with asteroids
• Irregular shapes
• Origin is uncertain

The Asteroid Belt

Eros

Eros

Minor members of the solar system

Comets
• Often compared to large, “dirty snowballs”
• Composition
  • Frozen gases
  • Rocky and metallic materials
• Frozen gases vaporize when near the Sun
  • Produces a glowing head called the coma
  • Some may develop a tail that points away from Sun due to
    • Radiation pressure and the
    • Solar wind

Orientation of a comet’s tail as it orbits the Sun

Minor members of the solar system

Comets
• Origin
  • Not well-known
  • Form at great distance from the Sun
• Most famous short-period comet is Halley's comet
76-year orbital period
Potato-shaped nucleus (16 km by 8 km)

**Comet Hale-Bopp**

**Orbits of Kuiper Belt Objects**

**Minor members of the solar system**

Meteoroids
- Called meteors when they enter Earth's atmosphere
- A meteor shower occurs when Earth encounters a swarm of meteoroids associated with a comet's path
- When they are found on Earth meteoroids are referred to as meteorites

**Iron meteorite found near Meteor Crater, Arizona**

**Minor members of the solar system**

Meteoroids
- Meteoroids are referred to as meteorites when they are found on Earth
- Types of meteorites classified by their composition
  - Irons
    - Mostly iron
    - 5-20% nickel
  - Stony
    - Silicate minerals with
    - Inclusions of other minerals

**Minor members of the solar system**

Meteoroids
- Types of meteorites classified by their composition
  - Stony-irons - mixtures
  - Carbonaceous chondrites
    - Rare
    - Composition - simple amino acids and other organic material
    - May give an idea as to the composition of Earth's core
    - Give an idea as to the age of the solar system

**The End !!!**