

1  **Planetary "Geology"**

***Earth 9<sup>th</sup> Edition - Chapter 24***

2  **Planetary Geology: summary in haiku form**

Can it be geo- ?  
When there's only one planet  
qualified as "Earth?"

3  **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.

4  **Overview of the solar system**

- Solar system includes
  - Sun
  - Eight planets and their satellites
  - Dwarf planets
  - Asteroids
  - Comets
  - Meteoroids

5  **The solar system**

6  **Overview of 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°

7  **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

8  **Overview of the solar system**

- 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

9  **The planets drawn to scale**

10  **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 (NH<sub>3</sub>)
  - ◆ Methane (CH<sub>4</sub>)
  - ◆ Carbon dioxide (CO<sub>2</sub>)
  - ◆ Water (H<sub>2</sub>O)
  - ◆

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

20  **Formation of lunar maria, stage one:**

21  **Formation of lunar maria**

22  **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

23  **Earth's Moon**

- Lunar surface
  - ☒ Craters
    - Ejecta
    - Occasional rays (associated with younger craters)

24  **Anatomy of an Impact Crater:**

25  **Anatomy of an Impact Crater:**

26  **Anatomy of an Impact Crater:**

27  **Anatomy of an Impact Crater:**

28  **Anatomy of an Impact Crater:**

29  **20-km wide crater Euler**

30  **Earth's Moon**

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

31  **Harrison Schmitt**

32  **Footprint in the Lunar "soil"**

33  **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

34  **Figure 24.9A,B**

35  **Figure 24.9C,D**

36  **Figure 24.9E**

37  **Planets: A brief tour**

- Mercury
  - Innermost planet

- Second smallest planet
- No atmosphere
- Cratered highlands
- Vast, smooth terrains
- Very dense
- Revolves quickly, rotates slowly

38  ***Photo mosaic of Mercury***

39  ***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

40  ***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

41  ***Computer generated view of Venus***

42  ***Computer generated view of Venus***

43  ***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

44  ***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

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

46  ***Pathfinder: first geologist on Mars***

47  ***The Valles Marineris canyon system on Mars***

48  ***Crater wall, water gullies***

49  ***Streamlined islands in Ares Valles***

50  ***Terraces and stream channel***

51  ***Patterned ground: permafrost?***

52  ***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

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53  ***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

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

55  ***Atmospheric structure***

56  ***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

57  ***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

58  **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

59  **Io**

60  **Europa**

61  **Ganymede**

62  **Callisto**

63  **Planets: A brief tour**

● Saturn

• Similar to Jupiter in its:

- ◆ Atmosphere
- ◆ Composition
- ◆ Internal structure

• Rings

- ◆ Most prominent feature
- ◆ Discovered by Galileo in 1610
- ◆ Complex

64  **Planets: A brief tour**

● Saturn

• Rings

- ◆ 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

65  **The ring system of Saturn**

66  **Planets: A brief tour**

● Saturn

• Other features

- ◆ Dynamic atmosphere
- ◆ Large cyclonic storms similar to Jupiter's Great Red Spot
- ◆ Thirty named moons
- ◆ Titan – the largest Saturnian moon
  - Second largest moon (after Jupiter's Ganymede) in the solar system
  - Has a substantial atmosphere

67  **Saturn & moons**

68  **Planets: A brief tour**

● Uranus

☒ Uranus and Neptune are nearly twins

☒ Rotates "on its side"

☒ Rings

☒ Large moons have varied terrains

69  **Uranus**

70  **Planets: A brief tour**

● 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

71  ***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

72  ***Neptune***

73  ***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 -210°C
  - International Astronomical Union added new class of dwarf planets in 2006

74  ***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

75  ***The Asteroid Belt***

76  ***Eros***

77  ***Eros***

78  ***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

79  ***Orientation of a comet's tail as it orbits the Sun***

80  ***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)

81  ***Comet Hale-Bopp***

82  ***Orbits of Kuiper Belt Objects***

83  ***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

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

85  ***Meteor Crater, Arizona***

86  ***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

87  ***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

88  ***The End !!!***