9.1 CONNECTING PLANETARY INTERIORS AND SURFACES

Our goals for learning:
- What are terrestrial planets like on the inside?
- What causes geological activity?
- Why do some planetary interiors create magnetic fields?

EARTH’S INTERIOR

- **Core**: Highest density; nickel and iron
- **Mantle**: Moderate density; silicon, oxygen, etc.
- **Crust**: Lowest density; granite, basalt, etc.
TERRESTRIAL PLANET INTERIORS

- Applying what we have learned about Earth's interior to other planets tells us what their interiors are probably like.

DIFFERENTIATION

- Gravity pulls high-density material to center.
- Lower-density material rises to surface.
- Material ends up separated by density.

LITHOSPHERE

- A planet's outer layer of cool, rigid rock is called the lithosphere.
- It "floats" on the warmer, softer rock that lies beneath.
HEATING OF INTERIOR

- Accretion and differentiation when planets were young
- Radioactive decay is most important heat source today

COOLING OF INTERIOR

- Convection transports heat as hot material rises and cool material falls
- Conduction transfers heat from hot material to cool material
- Radiation sends energy into space

ROLE OF SIZE

- Smaller worlds cool off faster and harden earlier
- Moon and Mercury are now geologically “dead”
WHAT HAVE WE LEARNED?
- What are terrestrial planets like on the inside?
  - Core, mantle, crust structure
  - Denser material is found deeper inside
- What causes geological activity?
  - Interior heat drives geological activity
  - Radioactive decay is currently main heat source
- Why do some planetary interiors create magnetic fields?
  - Requires motion of charged particles inside planet

9.2 SHAPING PLANETARY SURFACES
Our goals for learning:
- What processes shape planetary surfaces?
- Why do the terrestrial planets have different geological histories?
- How do impact craters reveal a surface’s geological age?

PROCESSES THAT SHAPE SURFACES
- Impact cratering
  - Impacts by asteroids or comets
- Volcanism
  - Eruption of molten rock onto surface
- Tectonics
  - Disruption of a planet’s surface by internal stresses
- Erosion
  - Surface changes made by wind, water, or ice
IMPACT CRATERING

- Most cratering happened soon after solar system formed
- Craters are about 10 times wider than object that made them
- Small craters greatly outnumber large ones

VOLCANISM

- Volcanism happens when molten rock (magma) finds a path through lithosphere to the surface
- Molten rock is called lava after it reaches the surface

LAVA AND VOLCANOES

Runny lava makes flat lava plains
Slightly thicker lava makes broad shield volcanoes
Thickest lava makes steep stratovolcanoes
Volcanism also releases gases from Earth’s interior into atmosphere.

Convection of the mantle creates stresses in the crust called tectonic forces.
Compression forces make mountain ranges.
Valley can form where crust is pulled apart.

Erosion is a blanket term for weather-driven processes that break down or transport rock.
Processes that cause erosion include:
- Glaciers
- Rivers
- Wind
EROSIONAL DEBRIS

- Erosion can create new features by depositing debris

ROLE OF PLANETARY SIZE

- Smaller worlds cool off faster and harden earlier
- Larger worlds remain warm inside, promoting volcanism and tectonics
- Larger worlds also have more erosion because their gravity retains an atmosphere

ROLE OF DISTANCE FROM SUN

- Planets close to Sun are too hot for rain, snow, ice and so have less erosion
- More difficult for hot planet to retain atmosphere
- Planets far from Sun are too cold for rain, limiting erosion
- Planets with liquid water have most erosion
ROLE OF ROTATION

- Planets with slower rotation have less weather and less erosion and a weak magnetic field.
- Planets with faster rotation have more weather and more erosion and a stronger magnetic field.

HISTORY OF CRATERING

- Most cratering happened in first billion years.
- A surface with many craters has not changed much in 3 billion years.

CRATERING OF MOON

- Some areas of Moon are more heavily cratered than others.
- Younger regions were flooded by lava after most cratering.
WHAT HAVE WE LEARNED?
- What processes shape planetary surfaces?
  - Cratering, volcanism, tectonics, erosion
- Why do the terrestrial planets have different geological histories?
  - Differences arise because of planetary size, distance from Sun, and rotation rate
- How does a planet’s surface reveal its geological age?
  - Amount of cratering tells us how long ago a surface formed

9.3 GEOLOGY OF THE MOON AND MERCURY
Our goals for learning:
- What geological processes shaped our Moon?
- What geological processes shaped Mercury?

LUNAR MARIA
- Smooth, dark lunar maria are less heavily cratered than lunar highlands
- Maria were made by flood of runny lava
FORMATION OF LUNAR MARIA

Early surface covered with craters  Large impact crater weakens crust  Heat build-up allows lava to well up to surface  Cooled lava is smoother and darker than

TECTONIC FEATURES

• Wrinkles arise from cooling and contraction of lava flood

GEOLOGICALLY DEAD

• Moon is considered geologically “dead” because geological processes have virtually stopped
CRATERING OF MERCURY

- A mixture of heavily cratered and smooth regions like the Moon
- Smooth regions are likely ancient lava flows

TECTONICS ON MERCURY

- Long cliffs indicate that Mercury shrank early in its history

WHAT HAVE WE LEARNED?

- What geological processes shaped our Moon?
  - Early cratering still present
  - Maria resulted from volcanism
- What geological processes shaped Mercury?
  - Cratering and volcanism similar to Moon
  - Tectonic features indicate early shrinkage
9.4 GEOLOGY OF MARS

Our goals for learning:
- How did Martians invade popular culture?
- What are the major geological features of Mars?
- What geological evidence tells us that water once flowed on Mars?

CRATERING ON MARS

- Amount of cratering differs greatly across surface
- Many early craters have been erased

VOLCANISM ON MARS

- Mars has many large shield volcanoes
- Olympus Mons is the largest volcano in our solar system
TECTONICS ON MARS

- System of valleys known as Valles Marineris thought to originate from tectonics.

DRY RIVERBEDS?

- Close-up photos of Mars show what appear to be dried-up riverbeds.

EROSION OF CRATERS

- Details of some craters suggest they were once filled with water.
MARTIAN ROCKS

- Mars rovers have found rocks that appear to have formed in water

HYDROGEN CONTENT

- Map of hydrogen content (blue) shows that low-lying areas contain more water ice

CRATER WALLS

- Gullies on crater walls suggest occasional liquid water flows happened less than a million years ago
WHAT HAVE WE LEARNED?

- How did Martians invade popular culture?
  - Surface features of Mars in early telescopic photos were misinterpreted as “canals”
- What are the major geological features of Mars?
  - Differences in cratering across surface
  - Giant shield volcanoes
  - Evidence of tectonic activity

WHAT HAVE WE LEARNED?

- What geological evidence tells us that water once flowed on Mars?
  - Features that look like dry riverbeds
  - Some craters appear to be eroded
  - Rovers have found rocks that appear to have formed in water
  - Gullies in crater walls may indicate recent water flows

9.5 GEOLOGY OF VENUS

Our goals for learning:
- What are the major geological features of Venus?
- Does Venus have plate tectonics?
CRATERING ON VENUS
- Impact craters, but fewer than Moon, Mercury, Mars

VOLCANOES ON VENUS
- Many volcanoes, including both shield volcanoes and stratovolcanoes

TECTONICS ON VENUS
- Fractured and contorted surface indicates tectonic stresses
EROSION ON VENUS

Photos of rocks taken by lander show little erosion.

DOES VENUS HAVE PLATE TECTONICS?

- Most of Earth’s major geological features can be attributed to plate tectonics, which gradually remakes Earth’s surface.
- Venus does not appear to have plate tectonics, but entire surface seems to have been “repaved” 750 million years ago.

WHAT HAVE WE LEARNED?

- What are the major geological features of Venus?
  - Venus has cratering, volcanism, and tectonics but not much erosion.
- Does Venus have plate tectonics?
  - The lack of plate tectonics on Venus is a mystery.