Introduction to Geology and its Scope

Dr. Mateen Hafiz | August 18, 2020

Department of Geology,
Govt. Maulana Azad Memorial (MAM) College, Jammu (India)

Introduction to Geology

- The word ‘Geology’ originated from the Greek words ‘*geo*’ meaning ‘Earth’, and ‘*logos*’ meaning ‘study or science’. Geology is the science or study of the Earth, its materials, processes that affect them, the products formed and the earth’s history since its birth, 4.54 billion years ago.
- Geology (also called ‘geoscience’), in general, deals with the study of various processes responsible for bringing out changes on the surface of the Earth, description of Earth materials, disposition of rocks and rock structures and geological history of the Earth. It encompasses studies that characterize the formation and composition of this planet, the causes of mountain building and ice ages, the record of life’s evolution, and the history of climate change.
- Geologists (who study geology) investigate geological phenomena such as earthquakes and volcanoes and attempt to predict and minimize their damaging effects. They also addresses practical problems such as how to keep pollution out of groundwater, how to find oil and useful minerals, and how to avoid landslides.

Branches of Geology

Name	Subject(s) of study
Engineering Geology	Study of application of geology to civil engineering; for understanding slope stability, or to building tunnels, dams, mines, roads, or foundations
Environmental Geology	Deals with the interactions between the environment and geologic materials, and contamination of geologic materials by pollutants
Geochemistry	This branch deals with the occurrence, distribution, abundance, mobility of different elements in the Earth's crust
Geochronology	The age (in years) of geologic materials, the Earth, and extra-terrestrial objects
Geomorphology	Formation and evolution of landscapes
Geophysics	Physical characteristics of the Earth (such as density and magnetism), and causes of forces in the Earth
Hydrogeology	Occurrence, movement and nature of groundwater and its reaction with rock and soil
Mineralogy	Physical properties, structure, and chemical behavior of minerals
Palaeontology	Fossils of ancient life forms and their evolution as preserved in the rock record
Petrology	Description of rocks and their formation
Sedimentology	Sediments and their deposition
Seismology	Earthquakes and the Earth's interior as revealed by seismic (earthquake) waves
Stratigraphy	The succession of sedimentary rock layers and the record of Earth's history that they contain
Structural Geology	Rock deformation (bending and breaking) in response to the application of force associated with mountain building
Tectonics	Origin and significance of regional-scale geologic features
Volcanology	Volcanic eruptions and their products, and volcanic hazards

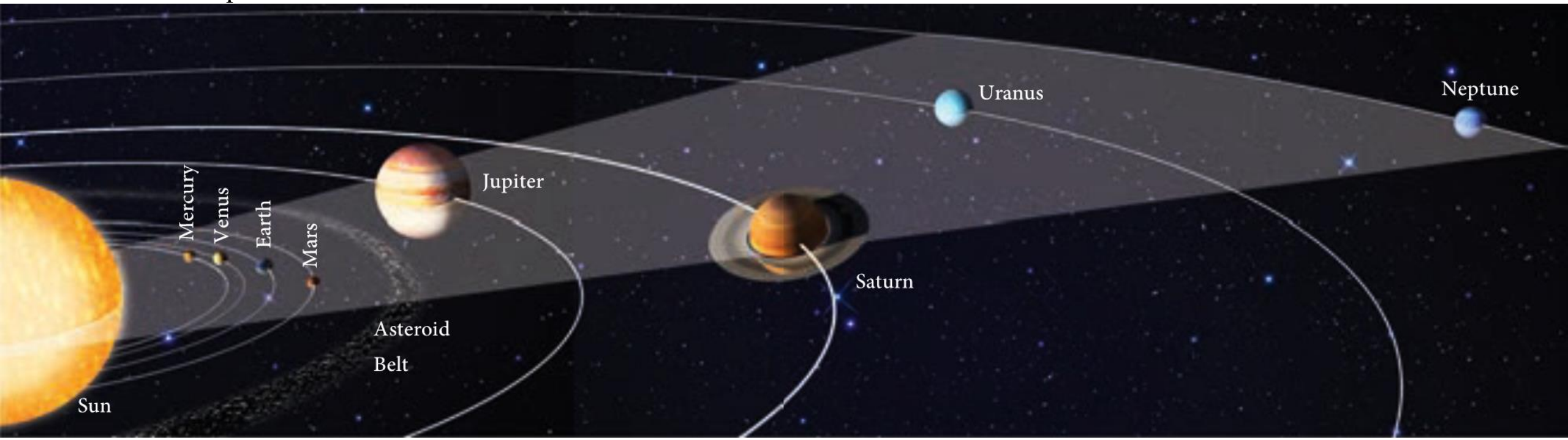
Scope of Geology

Geology is one of the most interesting and useful subjects for the layman and the knowledgeable people alike. This is the only subject which gives information about the Earth.

- First, geology may be one of the most practical subjects one can learn.
  - Geological knowledge may help in building homes on a hazardous floodplain or fault zone, on an unstable slope, or along a rapidly eroding coast.
  - With an understanding of groundwater, a good, suitable site for a tube well can be found.
  - The knowledge of the geologic controls on resource (oil and minerals) distribution will help in investing more wisely in the resource industry or understand the context of political choices regarding energy policy.
- Second, the study of geology gives an awareness of the planet that no other field can. The Earth is a complex world, where living organisms, oceans, atmosphere, and solid rock/soil interact with one another in multiple ways. Geologic study reveals the Earth's antiquity and demonstrates how this planet has changed profoundly during its existence.
- Third, the study of geology puts the accomplishments and consequences of human civilization in a broader context. Due to the technological advancements, the humans can change the landscapes of the Earth (For example, bulldozers clear a swath of forest, a dynamite explosion flatten the hills, or grasslands evolve into a housing colonies).
- Studying geology may inculcate the geological curiosity in students. The walk in the mountains will remind the geology students that the mountains rise and fall over time in response to tectonic forces that change the Earth's surface. A natural disaster may lead them to think about the various phenomena that trigger disasters.

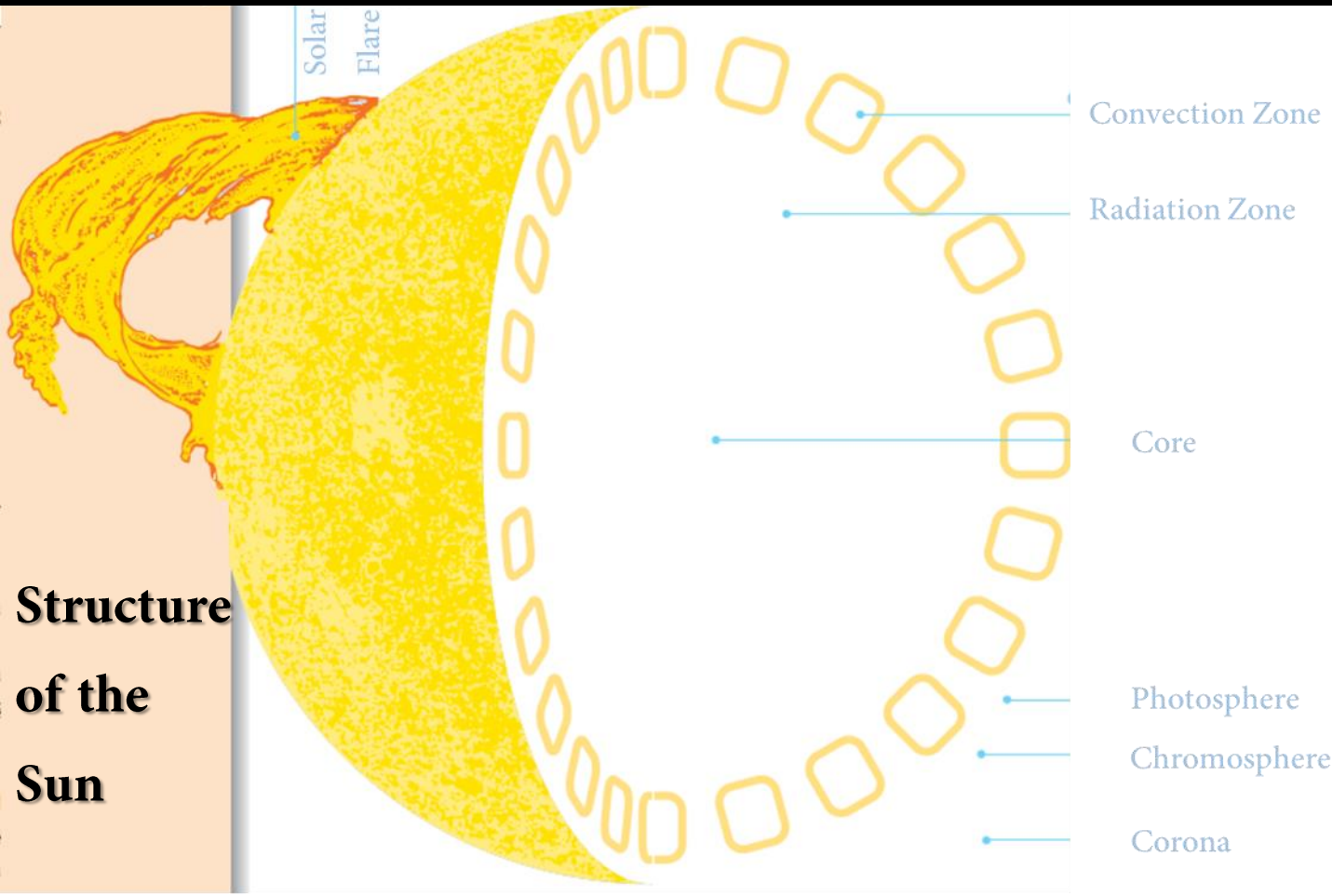
The Solar System

- An average sized star called the Sun holds many cosmic bodies by its gravitational pull which, together with the Sun, comprise the Solar System. These bodies include:
  a. The eight planets (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune)
  b. More than 130 satellites
  c. The comets and asteroids
  d. Interstellar Matter (ISM)
- The Sun contains 99.85 % of the solar system's known mass.
- The planets make up 0.135 % of all the matter within the solar system
- The Satellites of planets, comets, asteroids, meteoroids, and ISM, with 0.015 % share



The Sun orbits the center of the Milky Way at a distance of about 24,000–26,000 light years from the galactic center, and completes in 225–250 million earth years.

The Sun contains 99.85 % of the solar system's known mass.



Structure of the Sun

Core: At the heart of the Sun nuclear fusion reactions convert hydrogen into helium. Temperatures reach 15,000,000°C.

Radiation Zone: Energy produced in the core radiates toward the surface of the Sun through this region. This energy prevents the Sun from collapsing under the force of gravity.

Convection Zone: Energy waves, weakened by their passage through the radiation zone, pass through this area via constantly churning convection currents.

Photosphere "surface" of the Sun is highly irregular. Temperatures vary from 4,300–9,000°C.

Chromosphere is a highly agitated zone of thin gases rising to ~ 9,700 km above the photosphere. This region is constantly disrupted by solar flares, prominences, and spiricules.

Corona: Extending millions of miles into space the corona is a very thinly dispersed ball of gas. Atoms and molecules in this region have very high velocities and temperatures up to 4,000,000°C.

The Planets

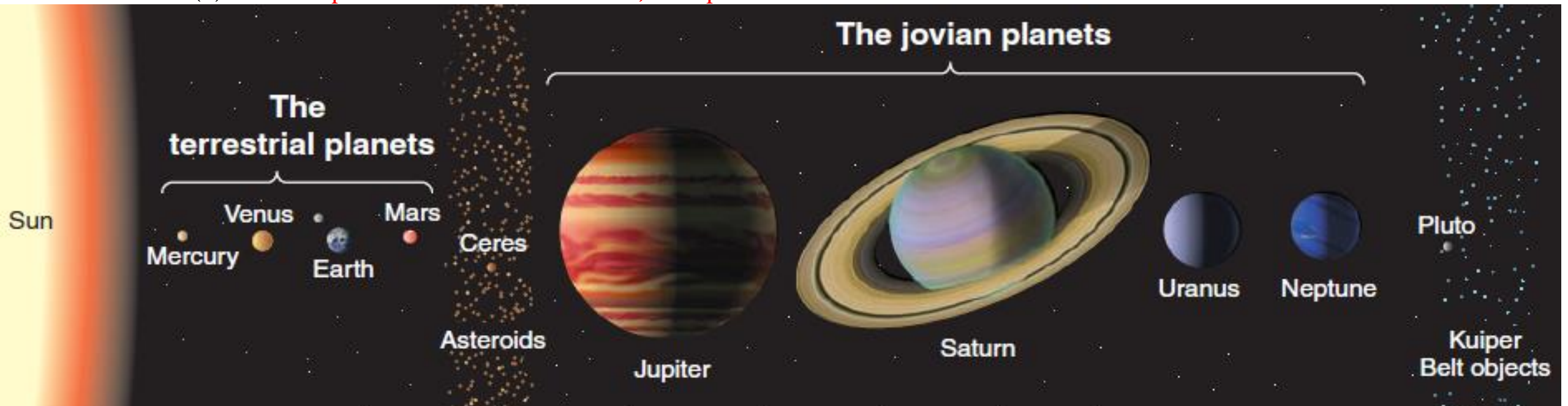
A planet as an object that orbits a star, is roughly spherical, and has "cleared its neighborhood of other objects". **Pluto** does not fit the modern definition of a planet as it has not cleared its orbit. All planets revolve around the Sun in the same direction in nearly circular orbits and in almost the same plane.

Planets in our Solar System differ radically from one another both in size and composition along with their respective distances from the Sun. Accordingly; the 8 planets conveniently fall into two groups:

(i) The inner planets (Mercury, Venus, Earth, and Mars), also called the Terrestrial Planets, because, like Earth, consist of a shell of rock surrounding a ball of metal and (ii) The outer planets also called the Giant or Jovian planets.

- Mass of Jupiter and Saturn mostly consists of H & He (also known as Gas giants).
- Uranus, and Neptune consists of solid water, ammonia, and methane so these planets are known as the ice giants.

Terrestrial planets lie closer to the Sun, have relatively smaller masses, slower speeds of rotation and are rich in silicon, magnesium and iron. Jovian planets, on the other hand, lie much farther, have very large masses, faster rotations, and are rich in volatiles like carbon dioxide, ammonia, ices of water and methane.



Meteoroid, Meteor and Meteorite

A meteoroid is 10 microns to 1 meter size natural solid object moving in interplanetary space. However, a meteoroid sometimes accidentally enters Earth's atmosphere and on its way to the Earth's surface catches fire due to friction with the gases in the atmosphere. A meteoroid after catching fire is known as a meteor or a shooting star. A meteor can, therefore, be defined as the visible path of a meteoroid that enters the Earth's atmosphere. Rarely, a meteoroid survives to reach the Earth's surface and whenever it does so, it is known as a meteorite.

A meteorite can thus be defined as a rock fragment dislodged from "a celestial body, launched into interplanetary space, which pass through the Earth's atmosphere and lands onto the surface".

As of 2019, there are more than 60,000 known meteorites. Most of them came from the asteroids, 190 are Martian members and 293 are lunar meteorites.

Moons

A moon is a sizeable body locked in orbit around a planet (natural satellite)
All but two planets (Mercury and Venus) have moons in varying numbers-
Earth has one, Mars has two, and Jupiter has atleast 63.

The Asteroid Belt

Asteroids are rocky and/or metallic objects, with diameters ranging from less than 1cm to about 930 km. Millions of asteroids occupy a belt between the orbits of Mars and Jupiter. These constitute a large Asteroid Belt.

The Comets

A comet is an icy planetesimal whose highly elliptical orbit brings it so close to the Sun that during part of its journey it evaporates and releases glowing gas and dust that forms a tail pointing away from the Sun.

Studies confirm that comets consist primarily of frozen water, carbon dioxide, methane, ammonia, and other volatile compounds, along with a variety of organic chemicals and dust (tiny rock or metallic particles).

The Moon orbits the Earth. It's composed of rock and hosts craters and large mare.

Questions to Consider

The study of layered rocks, especially their relative ages and correlation between different areas is called:

- ❑ Stratigraphy
- ❑ Geophysics
- ❑ Palaeontology
- ❑ Mineralogy

Name the region in the Sun, where atoms and molecules are having very high velocities and temperatures.

- ❑ Photosphere
- ❑ Chromosphere
- ❑ Corona
- ❑ Solar flares

Pluto is not a planet because:

- ❑ It is not revolving around the Sun
- ❑ It is spherical
- ❑ It hasn't cleared its neighborhood
- ❑ All of the above

A rock fragment launched into interplanetary space, which pass through the Earth's atmosphere and lands onto the surface is a:

- ❑ Meteoroid
- ❑ Comet
- ❑ Meteor
- ❑ Meteorite

Suggested Readings

Earth – Portrait of a Planet by Stephen Marshak

The atmosphere by Lutgens and Tarbuck

Earth's Dynamic Systems by Hamblin and Christiansen

Fundamentals of Physical Geology by Sreepat Jain

Text book of Engineering Geology by N. Chenna Kesavulu