Introduction to geoscience

by

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The Geosciences are among the most important fields of study in our highly technological world. Geoscientists study the earth, its atmosphere and its oceans to characterize its materials, understand the processes that shape it, and to unravel its history.
Important topics

• formation and evolution of the Earth
• composition and structure of the crust, mantle, and core
• Changes on surface and within the earth crust
• plate tectonics
Various fields of Geosciences

- Physical Geology / Geography
- Igneous Petrology
- Metamorphic Petrology
- Sedimentology & Stratigraphy
- Economic Geology
- Paleontology
- Geophysics
- Engineering geology
- Hydrogeology
- Natural Hazard
Earth history

• some geoscientists study changes in the Earth’s past, such as:
  • past climate
  • evolution of the atmosphere
  • ice ages
  • past plant and animal life
  • mass extinctions
  • human evolution
1. The Early Solar system

- **Big Bang Theory**
  (10-20 billions years ago, creation of matter through explosion)

- **Formation of Stars**
  (not permanent objects, formed from debris of Big Bang by local concentration of mass through gravity)

- **Formation of Sun & circulating Planet**
  (formed from rotating cloud of gas and dust. Sun shine due to the stored energy and crushing effect of its interior resulted in the nuclear reaction. The dust condensed from the cloud form rotating disks around young sun called planets. The process completed 4.5 billion years ago)
THE PLANETS

Planets proximal to sun

Planets more distal to sun

Planet distal to sun
THE PLANETS

• **Composition of planets**
  (depending how close is the planet to sun)

  • **Planet proximal to Sun**
    (contain metallic iron and mineral of HMT + water and gas)

  • **Planet distal to sun**
    (contain large amount of LMT minerals with some having water locked in crystal system)

  • **Planet more distal to sun**
    (contain original condensed gas as of very LMT)
### Table 1.1

**Some Basic Data on the Planets**

<table>
<thead>
<tr>
<th>Planet</th>
<th>Mean Distance from Sun (millions of km)</th>
<th>Equatorial Diameter, Relative to Earth</th>
<th>Density* (g/cu. cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>58</td>
<td>0.38</td>
<td>5.4</td>
</tr>
<tr>
<td>Venus</td>
<td>108</td>
<td>0.95</td>
<td>5.2</td>
</tr>
<tr>
<td>Earth</td>
<td>150</td>
<td>1.00</td>
<td>5.5</td>
</tr>
<tr>
<td>Mars</td>
<td>228</td>
<td>0.53</td>
<td>3.9</td>
</tr>
<tr>
<td>Jupiter</td>
<td>778</td>
<td>11.19</td>
<td>1.3</td>
</tr>
<tr>
<td>Saturn</td>
<td>1427</td>
<td>9.41</td>
<td>0.7</td>
</tr>
<tr>
<td>Uranus</td>
<td>2870</td>
<td>4.06</td>
<td>1.2</td>
</tr>
<tr>
<td>Neptune</td>
<td>4479</td>
<td>3.88</td>
<td>1.7</td>
</tr>
<tr>
<td>Pluto</td>
<td>5900</td>
<td>0.23</td>
<td>1.1</td>
</tr>
</tbody>
</table>

*Predominantly rocky/metal planets

Gaseous planets

*No other planets have been extensively sampled to determine their compositions directly, though we have some data on their surfaces. Their approximate bulk compositions are inferred from the assumed starting composition of the solar nebula and the planets’ densities. For example, the higher densities of the inner planets reflect a significant iron content and relatively little gas.*
Mars
(Ruddy, windswept surface, polar caps of carbon dioxide-ice)

Mercury
(Rocky, iron rich, dry, craters)

Jupiter
(Huge gas ball with no solid surface)

Neptune
(Another gas ball)
HISTORY OF THE EARTH

• Early earth
  (different from the present. Lacking no modern oceans and atmosphere. More or less resembling the present moon)

• Changing in Earth with Time
  (Decay of RA minerals, raise of internal T and slow melting. Dense material like Fe sink towards the middle. With progressive cooling the lighter material float to the surface. Process completed 4 billion years ago)

  » Core (iron with some Ni and minor elements)
  » Mantle (Fe, Mg, Si, O)
  » Crust (silicates)
• Composition of original Clouds
  (Study of meteorites by the Geoscientists)

• Formation of Atmosphere and Oceans
  (Due to early heating and differentiation, release of water and gases from the mineral structures. Cooling of the earth surface and condensation of clouds forming oceans)

• Earth Atmosphere
  (Change with time. Early atmosphere rich in N, CO2, no free O + minor methane, ammonia & sulfur gases released from volcanoes. Later appearance of single-celled blue-green algae, consumption of CO2 and release of O. Accumulation of more O and start of breathing-organism)
If earth history is equated to a 24 hours day, each hour equals about 190 my; modern thinking humans (Homo sapiens) arrived on the scene about ten seconds ago.
Mountain Ranges

- Himalayas
- K2
- Nanga Parbat
Physical Geology /Geography

- Alluvial Terrace
- Channel filled
- Braided channel
- Barchan Dunes
- Mountain Ranges (Ice cap / lake)
Sedimentology & Stratigraphy

Sandstone – Shale beds (Turbidites)

Horizontal strata, Great Canyon, Arizona

Fluvial cross bedding

Depositional contact
Metamorphic Petrology
Structural Geology

Faults

Ductile structures

Brittle structures

Folds
Economic Geology: Gems
Economic Geology: Ores

Gold and Copper Mine, Indonesia

Iron Mining

Open pit iron Mining

Copper mines dump
Economic Geology: Petroleum, Coal, etc.

Coal Mining

Oil Rigs
Paleontology

Fish fossil

Corals

Trilobites

Fossil Tree, petrified wood
Hydrogeology
Geophysics

**Release of energy away from fault**

**Seismograph:** Seismic body waves cause ground motion which is detected by Seismograph and, therefore, show the location of epicenter.
Hazards related to Geology: Earthquake, Tsunami
Land sliding
Plate Tectonics

• Tectonic Environments
  – Divergent Plate Boundary Environment
  – Convergent Plate Boundary Environment
  – Continental Collisional Environment
- Various types of rocks
- Metallic mineral resources
- Non-metallic mineral resources
- Energy resources
Mountains Building Processes
Formation of Himalayas

Moving plates
Highly stressed rocks
Folding in the rocks
Major topographic divisions of the north Atlantic Ocean

Figure 13.6
Active continental margin

Figure 13.8
Earth’s deep-ocean trenches

Figure 13.9
Slow spreading oceanic ridge

Figure 13.13A

Volcanoes
Rift valley
Pillow lavas
Sheeted dikes
Gabbro
Oceanic crust
Mantle
Magma chamber
Partial melting

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Fast spreading oceanic ridge

Figure 13.13B

- Pillow lavas
- Sheeted dikes
- Gabbro
- Volcanoes
- Magma chamber
- Partial melting
- Oceanic crust
- Mantle

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East African rift valley
Subduction of older (A) and younger (B) lithosphere

Figure 13.23
Earth’s major mountain belts

Key
- Young mountain belts (less than 100 million years old)
- Old mountain belts
- Shields
- Stable platforms (shields covered by sedimentary rock)

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Figure 14.3
Volcanic island arc

- Forearc
- Volcanic arc
- Backarc

Trench

- Oceanic lithosphere
- Subducting oceanic slab
- Melting

100 km

A. Volcanic island arc

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Figure 14.4A
Andean-type plate margin

Figure 14.4B
Thank you for your attention