

# UNIT – 1

## INTRODUCTION TO GEOMORPHOLOGY



Geology and Geophysics Department  
College of Science - King Saud University

## Course specification focus on

- Natural processes that create landforms and landscapes
- Physics and chemistry of weathering and soil formation
- Dynamics of mass wasting
- Streams and glaciers
- Karst processes
- Topographic response to tectonic and climatic forces
- Terrain analysis utilizing geomorphic field
- Data, remote sensing imagery, and numerical models
- Natural hazards.

# What do you see on the Earth's Surface

- We see various types of landforms on the Earth's surface which includes **mountains, hills, plateaus, plains, deserts, river valleys, river deltas, flood plains, cliffs, volcanoes** etc.
- **Landforms** are natural physical features of the Earth's surface.
- **Landforms** are the most visible features of the Earth and occur everywhere.
- They range in size from molehills to mountains to major tectonic plates, and their 'lifespans' range from days to millions of years.



# What is Geomorphology

- The word Geomorphology Named after three Greek words: *geo*: mean "earth" *morph*: mean form"; and *logos*: " means study";

Thus;

- ✓ Geomorphology **is the study of landforms and the processes that create them.**

and;

- ✓ Geomorphology is the science that studies the origin and development of landforms (such as hills, valleys, sand dunes, caves), and how those landforms combine to form landscapes.

Therefore, the

- ✓ Geomorphology is an important topic acts in the field of **1) Physical geography, 2) Geology, 3) Geodesy, 4) Engineering geology, 5) Archaeology and 6) Geotechnical engineering.**


# Applications of Geomorphology

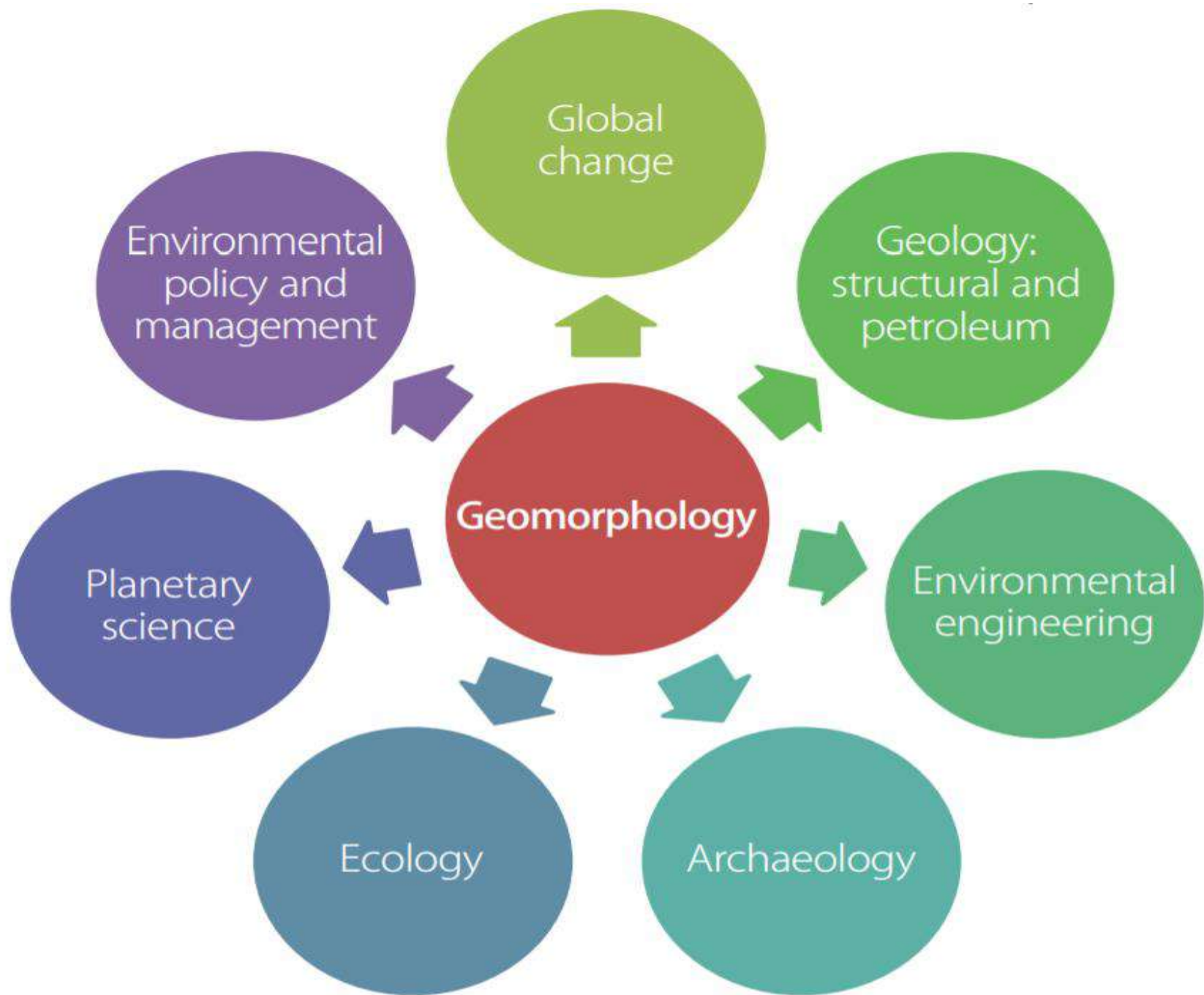
- Application of geomorphology is to clarifying **how landscapes/Landforms that had developed in the past**, **how they function at present**, and **how they might change in future**,

Thus;

- ✓ Geomorphology plays an important role in management and investigations issues:
  - For instance, structural geologists need to know how erosion effect on the Earth's surface influences patterns of rock deformation, and developing mountain belts.
  - Petroleum geologists are utilizing the modern-day depositional processes to understanding, to improve oil and gas subsurface exploration, and to assign how their reserves hosted in sedimentary rocks strata traps.

# Applications of Geomorphology

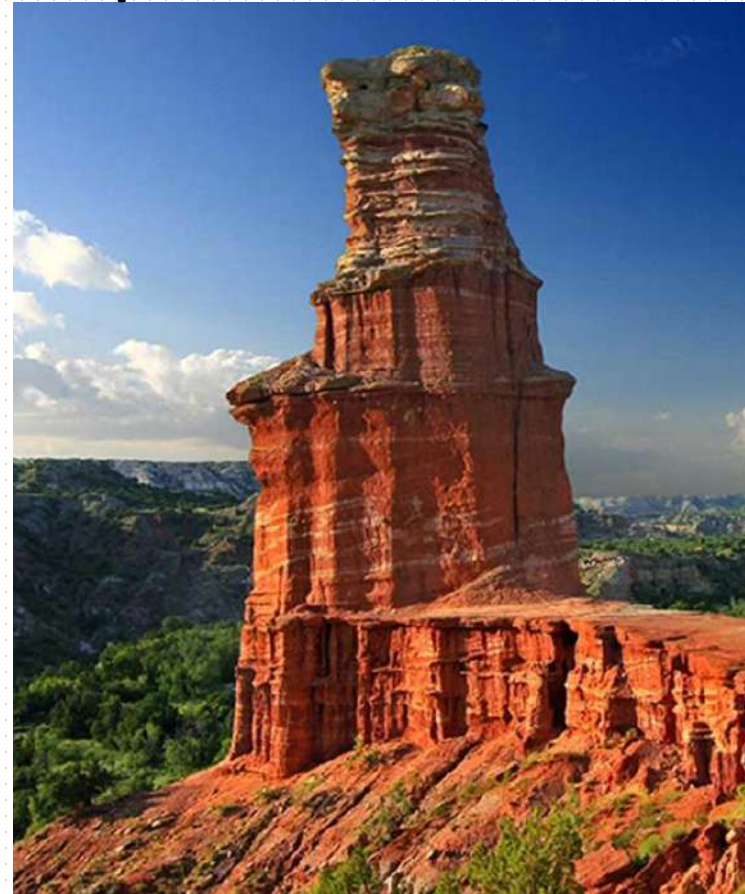
- **Engineers** are utilizing the knowledge of erosional and depositional processes to improve, and to estimate of the starting point of stability for hillslopes,  

  - to assess the probability of channel changes along rivers where infrastructural developments are planned.
- **Planetary scientists** are applying visions, which are gained from study of the Earth's landscape processes to help them interpret planetary surfaces.
- **Archaeologists** are interested in how erosional and depositional processes influence the preservation of artefacts and other forms of evidence for past human societies.





# Questions geomorphology can answer

- **What past processes created this landscape?**
- **What modern processes are modifying it?**
- **Where the processes that created this landform destructional or constructional?**
- **Are the modern processes modifying this landscape destructional or constructional?**



# Tools for geomorphological studies

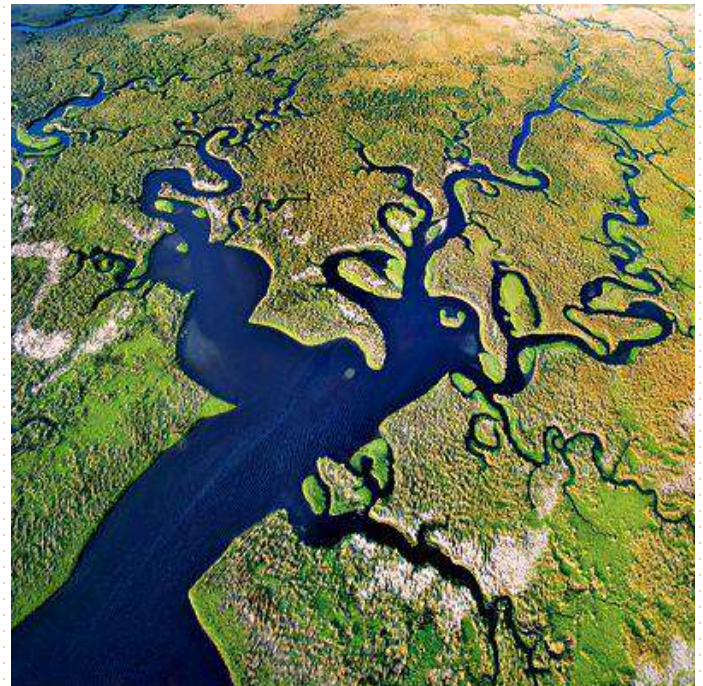
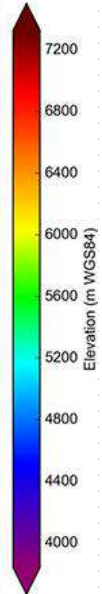
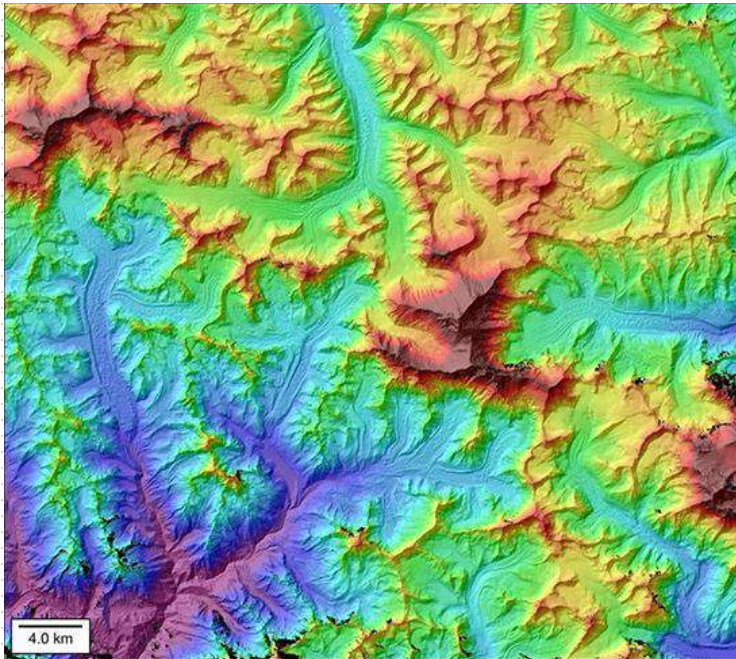
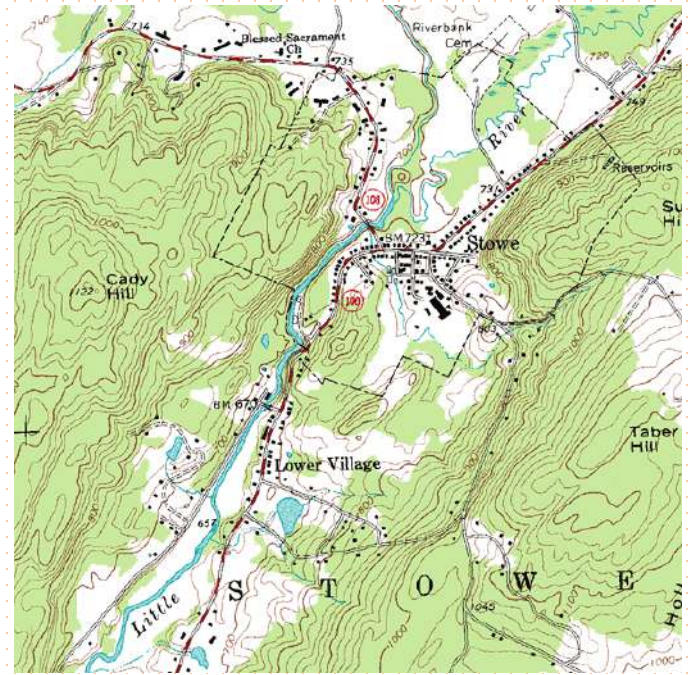
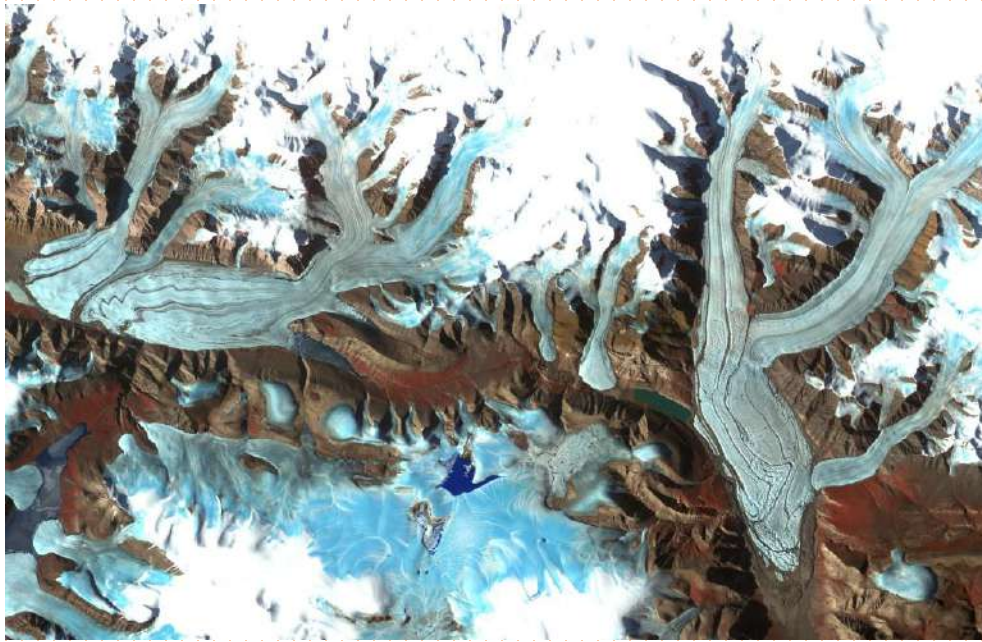
- **Geomorphological study; Traditionally; focused mainly on the field observations, description and measurement but also included physical experimentation (e.g. in small field plots or using laboratory flumes).**
- **Since the early 1970s, however, high-resolution images of the surface topography of the Earth and other planets have been acquired at rapid pace from a variety of satellites and spacecraft.**
  - ✓ **Many of these images are now readily available for free through the internet (e.g. using virtual globes such as Google Earth).**

# Tools utilized for geomorphological studies

- A large numbers of computer-based topographic models (e.g. Digital Elevation Models) have become readily available, and ground-based monitoring, computational modelling, and geochronological (dating) techniques (e.g. luminescence, cosmogenic isotope analysis) have developed and advanced rapidly.

Consequently;

- ✓ The traditional geomorphological study approaches and are combined commonly with these new images, models and techniques to quantify rates and timescales of landform change nowadays.
- It is now possible to view, measure, age, and model a variety of landforms and landscapes in ways that were incredible even a time ago.



# Significance of Geomorphology

- To understand geomorphological processes operating in different environments.
- To detect natural and environmental hazards efficiently, e.g. earthquake, flooding, landslide, tsunami, volcanism etc.
- To identify various landform features and landscapes.
- To identify various landform features from satellite images.
- Useful in Geology, Geography, Archeology, Engineering, Planning, Mining, Construction, Urbanization.



# Reasons for studying geomorphology

- **Landscape shaping are influenced by many different and processes or factors:** Landforms are shaped by geomorphological processes, which essentially involve of 1) the movement of mass – rock, 2) sediment, 3) water – across the Earth's surface.
- **Landscape processes operate at many different scales:** The tectonic, geological, climatic and ecological factors that influence geomorphological processes and movement of mass change with different time and space scales.
- **The Earth's landscapes are dynamic:** Landforms and landscapes are not static and unchanging, but are dynamic and developed through time.
- **Landscapes are archives of the past:** Landscapes contain histories of their development that potentially can be interpreted and reconstructed from study of the associated landforms and sediments.

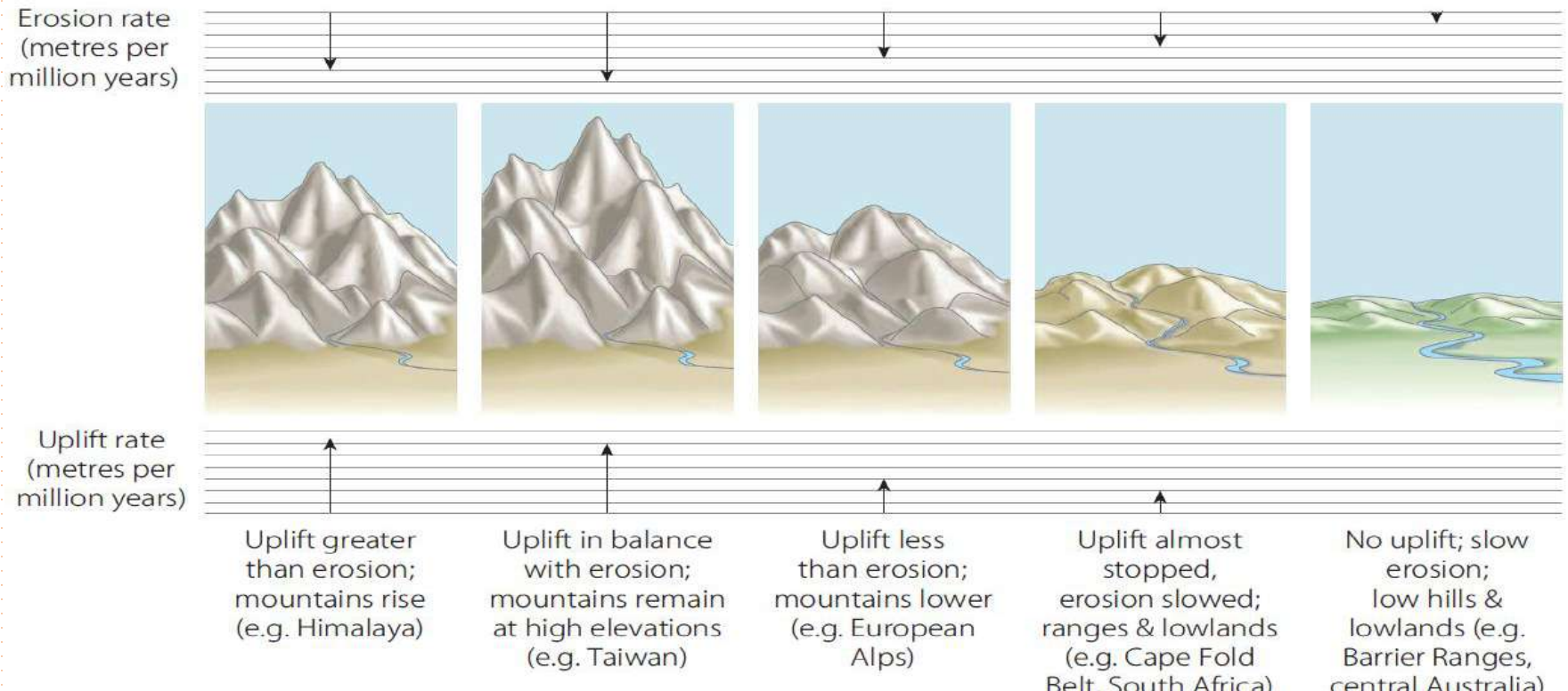
## Reasons for studying geomorphology

- **Global change is influencing landscape dynamics:** Ongoing global environmental change, which includes atmospheric warming and sea level rise, is currently driving landform development, including desert lake desiccation, ice sheet and glacial retreat, and coastline erosion.
- **Human activities are influencing landscape dynamics:** geomorphological processes and landform/landscape developments are influenced increasing by human activities.
- **The Earth's landscapes are becoming more hazardous:** Both global environmental change and human activities are increasing the magnitude and frequency of geomorphological hazards, which occur wherever and whenever land surface stability is affected and adverse socioeconomic impacts are experienced.

Thus,

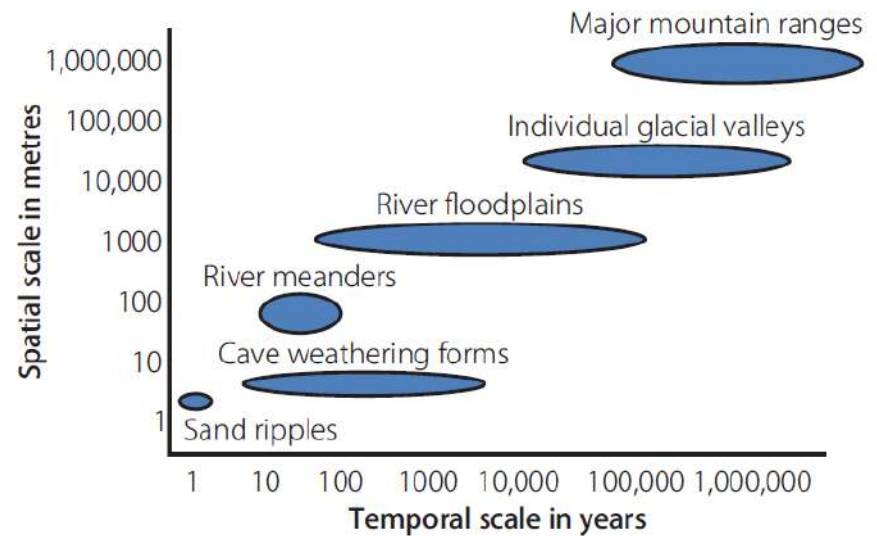
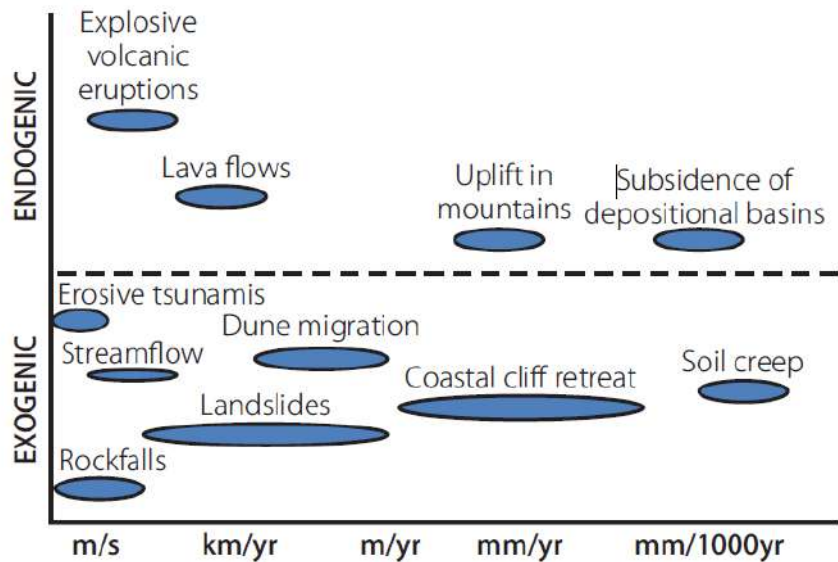
## Landscapes are shaped by movements of mass

- Landforms are shaped by geomorphological processes, which essentially involve the movement of mass – rock, sediment, water – across the Earth's surface.
- Movement of mass commonly involves the weathering, erosion, transportation and deposition of surface materials by gravity, ice, wind, or water, but can also involve near-surface tectonic, volcanic or groundwater activity.





# Landscape processes operate at many different scales



- Geomorphological processes are driven by endogenic factors (powered from within the Earth such as volcanoes and earthquakes) and exogenic factors (powered by the sun's energy and working through the climate system, such as rain, wind and waves).
- **Different processes result in different rates** for the movement of mass, from very slow (e.g. basin subsidence, soil creep) to extremely rapid (e.g. volcanic eruptions, rock falls)

- Landforms vary widely in spatial scale (size), and their development occurs across a wide range of time-based scales.
- **Small scale landforms** such as sand ripples form, erode and re-form on rapid temporal scales, while large scale landforms such as mountain ranges develop over far longer temporal scales

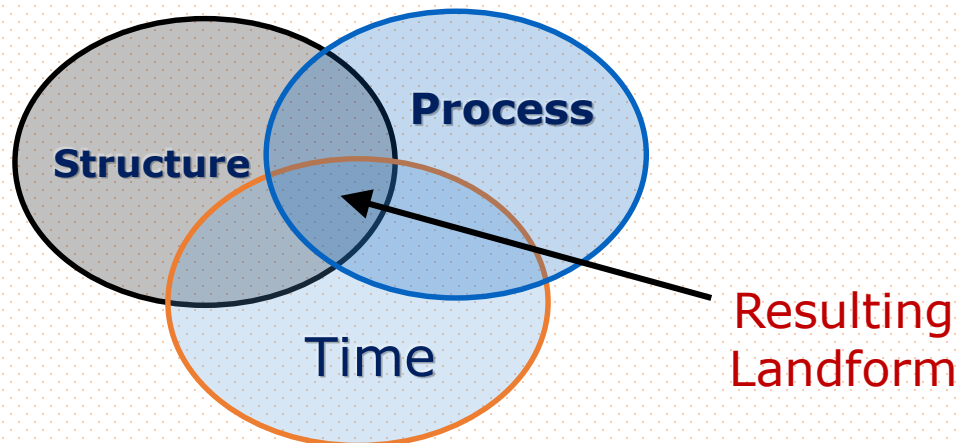
# Scale and Age of Landforms

- ❖ **Scale of landforms** varies over 15 orders of magnitude
  - Continents ( $10^7$  km<sup>2</sup>) to microscale features like ripples, glacial striations ( $10^{-8}$  km<sup>2</sup>)
- ❖ **Age of landforms** varies over 7-8 orders of magnitude
  - Continents ( $10^9$  years) to microscale features like pools and riffles ( $10^2$  years)
- ❖ **Larger landforms most geomorphic durable and created/destroyed slower (longer-lasting)**
- ❖ **Smaller landforms created/destroyed faster than larger ones**
- ❖ **Rates of geomorphic / geologic change slow for larger areas,**
- ❖ **Faster when measured over small areas.**
  - example: earthquakes compared to glaciers
  - Rate of erosion in small watershed compared to larger one.

# Factors control Landform Formation

➤ Thus, the Landforms can be explained as one or via a combination of the following idea introduced by **William Morris Davis** :

- ✓ **Structure:** rock mass (or unconsolidated material mass).
- ✓ **Process:** constructive or destructive process(es) acting now or previously on structure.
- ✓ **Time (stage):** landforms evolve through stages from continued actions of geomorphic process(es).



# Geomorphic Landforms Process

- The formation and deformation of landforms on the surface of the earth are a continuous process which is due to the continuous influence of external and internal forces.
- The internal and external forces causing stresses and chemical action on earth materials and bringing the changes and the configuration of the surface
  - known as geomorphic processes and as shown in the following flowchart:

# GEOMORPHIC PROCESSES

## Terrestrial Processes

## Extra-terrestrial Processes

### Exogenic Process

### Endogenic Process

- i. Weathering
- ii. Erosion/Degradation
- iii. Transportation
- iv. Deposition/Aggradation
- v. Mass movement

- i. Faulting and Folding
- ii. Volcanism
- iii. Earthquake
- iv. Landslide
- v. Diastrophism
- vi. Metamorphism

### Denudation

- Physical Weathering
- Chemical Weathering
- Biological Weathering



# Geomorphic Landform Process (Endogenic)

- **Endogenic forces** are those internal forces which derive their strength from the earth's interior and play a crucial role in shaping the earth crust.
  - ✓ Examples – mountain building forces, continent building forces, earthquakes, volcanism etc.
- The endogenic forces are mainly land building forces.
- **The energy originating within the earth, which is the main force behind endogenic geomorphic processes.**
  - ✓ This energy is mostly generated by radioactivity, rotational and tidal friction and primordial heat from the origin of the earth.

# Geomorphic Landform Process (Exogenic)

- **Exogenic forces are those forces which derive their strength from the earth's exterior or are originated within the earth's atmosphere, such as.**
  - ✓ Examples of forces – the wind, waves, water etc.
  - ✓ Examples of exogenic processes – weathering, mass movement, erosion, deposition.
- **Exogenic forces are mainly land wearing forces.**
  - ✓ **Weathering** is the breaking of rocks on the earth's surface by different agents like rivers, wind, sea waves and glaciers.
  - ✓ **Erosion** is the transporting broken rocks (Debris) from one place to another by natural agents like wind, water, and glaciers.



# Branches of Geomorphology

- The two main corresponding branches of geomorphology are **historical geomorphology** and **process geomorphology**.

## Historical geomorphology

- tends to focus on the histories of land scape evolution and adopts a successive, chronological view

Thus,

- ❖ The Historical geomorphologists consider historical process of explanations of their landform evolution.

## While, Process geomorphology

- tends to focus on the mechanics of geomorphic processes and process–response relationships (i.e. how geomorphic systems respond to disturbances).

Thus,

- ❖ The process to configure the earth's surface due to physical and chemical actions on present earth's materials to produce landforms.

Therefore;

- **Historical geomorphology** is the study of landform evolution or changes in landforms over medium and long timescales, usually timescales well be beyond the span of an individual human's experience on centuries, periods, millions and hundreds of millions of years.
- It brings in the historical dimension of the subject and relies mainly on the rocks **landform surface and on their records for its databases.**
- ❖ It depends on on the principal: **the present is the key to the past.**
  - It means that the effect of geomorphic processes acted today may be used to infer the causes and assumed that the landscape changes in the past.

# The Geomorphic/Geographic Cycle

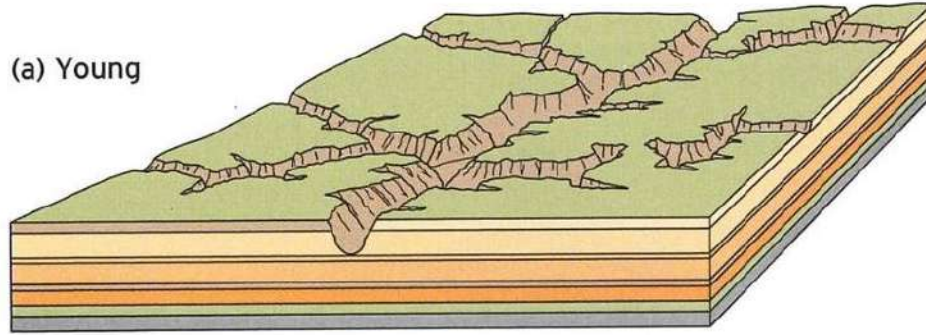
- The geomorphic cycle/geographical cycle', were given by William Morris Davis, They were the first modern theory of landscape evolution (e.g. Davis 1889, 1899, 1909).
- ✓ **Geomorphic processes**, without further complications from tectonic movements, gradually wear down the raw topography.
- ✓ **Furthermore, the slopes within landscapes decline through time : maximum slope angles gradually decrease.**

So.

- ❖ **The topography is reduced, little by little, to be an extensive base flat level region called peneplain.**

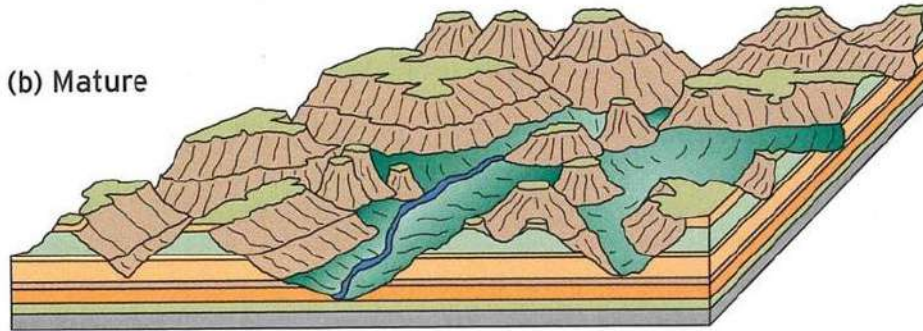
# The Geomorphic/Geographic Cycle

(a) Young



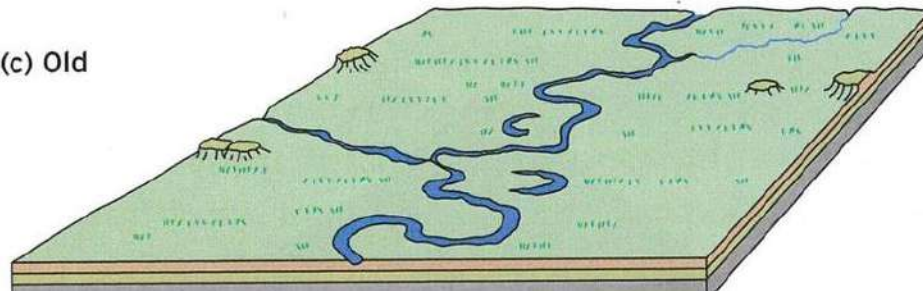
Recently uplifted with new incision

(b) Mature



Deep and widespread valley incision

(c) Old



# The Geomorphic/Geographic Cycle

➤ The **reduction process** creates a time sequence of landforms that progress through the stages of **youth, maturity, and old age**.

➤ The '**Geographical cycle**' designed to account the development of humid moderate landforms produced by continued wearing down of uplifted rocks offering uniform resistance to erosion.

□ **Geographical cycle** was extended to other landforms, including arid landscapes, glacial landscapes, periglacial landscapes, to landforms produced by shore processes, and to karst landscapes.

# Process of Geomorphology

➤ **Process of geomorphology** is the study of the processes responsible for landform development.

❖ **Three main contribution of process geomorphologists are:**

1. **A database of process rates in various parts of the globe (measurement of geomorphic process).**
2. **Highly refined models for predicting the short-term (and in some cases long-term) changes in landforms (modeling geomorphic process).**
3. **Thoughts, views about stability and instability in geomorphic systems.**

## Other Branches of Geomorphology

- Although process and historical studies dominate much modern geomorphological, but there are some other Geomorphology studies are occurred, such as:
  - ✓ For example, **structural geomorphologists**, argued that underlying geological structures are the key to understanding many landforms.
  - ✓ Today, other geomorphological studies include **applied geomorphology**, **tectonic geomorphology**, **submarine geomorphology**, **climatic geomorphology**, and **planetary geomorphology**.

# Questions



# Put right or false

- Landscape shaping processes are influenced by many different factors. **R**
- Landscapes are archives of the past. **R**
- Human activities are not influencing landscape dynamics. **F**
- The Earth's landscapes are becoming more hazardous. **R**
- If the uplift is greater than erosion mountains lower. **F**
- If the uplift almost stopped mountains rise. **F**
- No uplift, slow erosion = low hills. **R**
- Explosion volcanic eruptions are as a result of exogenic factors. **F**
- landslides are of exogenic factors. **R**
- Larger landforms most durable. **R**
- mountain building forces, continent are examples of exogenic processes. **F**
- The endogenic forces are mainly land building forces. **R**

- Exogenic forces are mainly land wearing forces. R
- weathering, erosion, and deposition are example of exogenic processes. R

# Complete

- two complementary main branches of geomorphology are .....and .....  
**historical geomorphology**  
**process geomorphology**
- The progress stages of landforms are.....,....., .....  
**youth, maturity, and old age**

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# Complete

## Exogenic processes include:

- .....
  - .....
  - .....
  - .....
  - .....
- Weathering
  - Erosion
  - Transportation
  - Deposition
  - Mass movement

## Types of weathering are:

- .....
  - .....
  - .....
- Physical weathering
  - Chemical weathering
  - Biological weathering

# Define

- **Historical geomorphology**
- **Process Geomorphology**