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| **Syllabus- 4th Sem, 2025, NEP (Geomorphology)** | 18.   Rocks |
| 1.       History of Geomorphology. | 19.   Minerals |
| 2.       Recent trends | 20.   System concept |
| 3.       Post-modern geomorphology | 21.   Steady-state |
| 4.       Branches of geomorphology | 22.   Dynamic Equilibrium |
| 5.       Theoritical geomorphology | 23.   Kober theory |
| 6.       Applied geomorphology | 24.   Holmes theory |
| 7.       Structural geomorphology | 25.   Continental drift |
| 8.       Fluvial geomorphology | 26.   Plate tectonic |
| 9.       Glacial geomorphology | 27.   Isostasy |
| 10.   Arid geomorphology | 28.   Endogenetic Processes |
| 11.   Glacial geomorphology | 29.   Exogenetic Processes |
| 12.   Environmental geomorphology | 30.   W. Penck theort |
| 13.   Paleo geomorphology | 31.   L. C. King theory |
| 14.   Structure of the earth | 32.   Fluvial Process |
| 15.   Composition of the earth | 33.   Glacial Process |
| 16.   Earth’s crust | 34.   Aeolian Process |
| 17.   Interior of the earth | 35.   Slope forming process |

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| Sylla  bus | Important Questions |
| 1 | 6. Discuss the nature and scope of geomorphology.—5 |
| 1 | 52. Write the development of Geomorphology after World War-II. – 5 |
| 2 | 7. Discuss recent trends in the study of geomorphology. ---6 |
| 3 | 51. Write the concept of Post- modern geomorphology. – 5 |
| 5 | 36. Write the scope of Tropical Geomorphology. – 4 |
| 6 | 53. Distinguish between Theoretical and Applied geomorphology. – 6 |
| 7 | Write short note on Structural geomorphology- 5 |
| 8 | Write short note on Fluvial geomorphology- 5 |
| 9 | 43. Arête is the term associated with ----- topography. –1 |
| 10 | 21. Analysis the processes of land form development under Arid Cycle of erosion. -10 |
| 10 | 39. Residual hill in the desert region is known is -------------. 1 |
| 10 | 42. Barchan is associated with ------- topography. –1 |
| 10 | 47. Mush room rocks created by the action of----------. –1 |
| 10 | 55. Write the name of erosional features of Aired region. – 3 |
| 10 | 62. Write two differences between Sand Dunes and Loess. – 2 |
| 10 | 74. Mention the name of five geomorphic features developed due to wind erosion. – 5 |
| 11 | 72. Name four geomorphic features developed in fifferent stages of a Glacial cycle of erosion. -2 |
| 11 | 75. Describe the geomorphic features formed due to erosional activity of glaciers.- 10 |
| 12 | Write short note on Environmental geomorphology- 5 |
| 13 | 56. Distinguish between Environmental and Palaeogeomorphology. – 6 |
| 14 | 19. Describe with neat diagrams the structure and composition of Earth’s crust. –10 |
| 14 | 24. What is the average density of the earth? -1 |
| 15 | Write about the composition of earth |
| 16 | 17. Write the concept of continental crust. – 5 |
| 17 | 31. Write the characteristics of Sima. – 3 |
| 17 | 35. Write the compositional characteristic of the Earth’s interior. – 5 |
| 17 | 48. Write short note on – Sial layer/ Rift valley/ delta/ flood plain. – 3 |
| 17 | 63. The zone of the earth’s interior which is mainly composed of silicate and magnesium. – 1 |
| 18 | 29. Conglomerate is a type of ----------------. |
| 18 | 65. Distinguish between Stratified rock and Metamorphic rock. – 6 |
| 19 | 57. Distinguish between rocks and minerals. – 6 |
| 20 | Write about the system concept in geomorphology |
| 21 | 16. Different the term Geodynamics. – 5 |
| 21 | 33. what is steady State?- 1 |
| 21 | 34. Who coin the term stady state? – 1 |
| 22 | 32. What is Eustatism? – 3 |
| 22 | 58. Write the concept of Dynamic equilibrium. – 5 |
| 23 | 22. Describe the mountain building process as explained by Kober. – 10 |
| 23 | 27. With which theory in geomorphology the term Randketten is associated? – 1 |
| 24 | 80. Write about the convection current theory of Holms. |
| 25 | 18. Discuss the Wegner’s views on disintegration of Pangaea. – 6 |
| 25 | 25. Give the name of the norther block of the Pangaea. – 1 |
| 25 | 41. Who proposed the continental drift theory. –1 |
| 25 | 76. Who postulated the theory of continental drift.- 1 |
| 26 | 10. Write the concept of plate tectonic. --- 6 |
| 26 | 20. Mention the major plates of the Earth with suitable diagram.—8 |
| 27 | 5. Define the term isostasy. Discuss how the Isostasy theory helps interpreting the major relief features of the earth.—2+8=10 |
| 27 | 26. Who was the first to proposed the term Isostasy? – 1 |
| 28 | 3. Classify the geomorphic processes. –3 |
| 28 | 4. Describe the landforms and processes associated with the development of faulted topography—8 |
| 28 | 15. Discuss the mechanism and phases of formation of folded mountains. – 6 |
| 28 | 30. Who discover Richter scale in 1935? - 1 |
| 28 | 37. Distinguish between orogenic and epeiorgenic movements. – 5 |
| 28 | 38. Write the impact of earth quake. – 4 |
| 28 | 46. what is youngest folded mountain in India? |
| 28 | 49. Write the causes of earthquake and volcanos. – 6 |
| 28 | 61. Write two differences between Anticline and Syncline. -2 |
| 28 | 64. To which order of landform does the ocean belong?. 1 |
| 28 | 70. State the meaning of endogenetic force. -2 |
| 28 | 71. What do you mean by order of landforms? In which order of landforms the continents and ocean basin are included? -2 |
| 28 | 77. Name four folded mountain of the world. – 2 |
| 28 | 78. Mention the three waves of earthquake.- 2 |
| 29 | 9. Discuss the Mass wasting processes. --- 6 |
| 29 | 11. Write short note on weathering—5 |
| 29 | 12. Write short note on erosion—5 |
| 29 | 13.Discuss the different types of mass wasting—5 |
| 29 | 40. Write the processes of Chemical weathering. – 4 |
| 29 | 67. Name two landform created by exogenetic forces. -1 |
| 29 | 68. Give an example of chemical weathering. -1 |
| 29 | 73. Mention any four process of physical weathering. -2 |
| 29 | 79. What are the agents of exogenetic process.- 3 |
| 30 | 8. Write short note of the views of W. Penck on land form development.—6 |
| 31 | 1. Distinguish between peneplain and pediplan. -3 |
| 31 | 2. Explain the prosesses involved in the formation of peneplain and pediplain with examplene.6 |
| 32 | 14. Discuss the views W.M. Davis on landform development. – 5 |
| 32 | 44. Write short note on –(a). Inselberg, (b). Hanging valley, (c). Runoff. (d) Alluvial fan, (e) moraine. —4 |
| 32 | 45. Who proposed Normal Cycle of erosion theory/ --1 |
| 32 | 54. Distinguish between Fluvial and Glacial geomorphology. – 6 |
| 32 | 66. Write four name of erosional feature formed by river. – 2 |
| 32 | 69. What are the three stages of cycle of erosion. – 2 |
| 33 | 23. write short note on carust landforms and Hanging Valley. – 5 |
| 34 | 28. Bergschrund is a feature of -------------- topography. –1 |
| 34 | 50. Write the characteristics of land form in limestone region—6 |
| 34 | 59. Write about the Aeolian process in land forms development.- 5 |
| 35 | 60. Write about the slope forming processes. – 5 |

***1.What is geomorphology?***

Ans- Geomorphology is the scientific study of landforms, their origin, classification, agents in developing landforms, description and application of its knowledge in present situations. The word geomorphology has been derived from the Greek word **“ge-meaning** the Earth, **morphe-meaning** form, and **logos-meaning** the discourse” Thus geomorphology means a discourse of the various forms of the Earth. It is a part of physical geography which deals with the study of landforms, their characteristics and various processes i.e. physical, chemical, biological and extra-terrestrial responsible for their formation and changes. The study of geomorphology encompasses how various agents like water, air, ice, etc. shape the topography of the Earth’s surface.

***2. History and Development of Geomorphic Ideas.***

The evolution of geomorphic ideas reflects humanity's growing understanding of Earth's surface processes and landforms over time. From early observations to modern scientific theories, geomorphology has developed through distinct phases, influenced by geology, physics, biology, and environmental science.

### **1. Early Observations (Pre-Scientific Period)**

* **Greek Contributions**:
  + **Herodotus (484–425 BCE)** observed sediment deposition by rivers like the Nile.
  + **Aristotle (384–322 BCE)** recognized processes like erosion and sediment transport.
* **Roman Contributions**:
  + Roman philosophers studied soil erosion and sedimentation for agricultural

### **2. Transition to Scientific Thought (16th–18th Century)**

* **Renaissance Era**:
  + Emphasis on empirical observations began to replace mythological explanations.
  + **Leonardo da Vinci (1452–1519)** noted evidence of ancient seas in fossil-bearing rocks on mountains.
* **17th Century**:
  + **Nicolas Steno (1638–1686)** developed the principles of stratigraphy, laying the foundation for understanding rock layers.
  + **James Hutton (1726–1797)** introduced the concept of **uniformitarianism**, proposing that the processes shaping Earth's surface today (e.g., erosion, deposition) operated similarly in the past.

### **3. 19th Century: Formalization of Geomorphology**

* **Catastrophism vs. Uniformitarianism**:
  + **Catastrophists** believed Earth's surface was shaped by sudden, short-lived events (e.g., floods). On the other hand, Uniformitarianism, championed by **Charles Lyell** in his Principles of Geology (1830), argued for gradual changes over immense time scales.
* **G.K. Gilbert (1834–1911)**:
  + Introduced the concept of equilibrium in geomorphic systems. He studied fluvial processes, graded streams, and the balance between erosion and deposition.
* **William Morris Davis (1850–1934)**:
  + Proposed the **cycle of erosion** model, describing landscape evolution through stages (youth, maturity, old age). His ideas, though later criticized, dominated early 20th-century geomorphology.

### **4. 20th Century: Process Geomorphology**

* **Quantitative Revolution (1950s–1970s)**:
  + Shift from descriptive models to quantitative analysis using mathematical models and field measurements. **Walter B. Langbein** and **Luna Leopold** studied river morphology and hydrology, emphasizing process-based understanding.
* **Dynamic Equilibrium**:
  + **John Hack (1960)** introduced the concept of dynamic equilibrium, challenging Davis's cycle of erosion. According to him landforms were seen as products of ongoing adjustments to environmental conditions.
* **Advances in Tectonic Geomorphology**:
  + Integration of plate tectonics with geomorphology explained the role of tectonic forces in shaping landscapes.

### **5. Modern Geomorphology (21st Century)**

* **Technological Advances**:
  + Use of remote sensing, GIS (Geographic Information Systems), and LiDAR to map and analyze landforms in detail.
  + Computer models simulate geomorphic processes over time.
* **Interdisciplinary Approaches**:
  + Integration of ecology, climate science, and human geography to study human-environment interactions.
* **Global Climate Change**:
  + Increasing focus on how climate change affects geomorphic processes, such as glacial retreat, sea-level rise, and desertification.
* **Dynamic Systems Theory**:
  + Landscapes are seen as open systems influenced by internal (e.g., erosion) and external (e.g., tectonic) forces, with feedback loops and thresholds.

### **Key Themes in Geomorphic Development**

1. **From Descriptive to Quantitative**:
   * Early geomorphology focused on describing landforms, while modern approaches emphasize processes and rates.
2. **Integrating Tectonics**:
   * Understanding the interplay between tectonics and surface processes is a major development in the field.
3. **Human Impact**:
   * Recognition of anthropogenic factors, such as deforestation, urbanization, and mining, influencing geomorphic processes.
4. **Focus on Sustainability**:
   * Application of geomorphology in environmental management and disaster risk reduction.

The history of geomorphic ideas reflects a transition from mythological interpretations to sophisticated scientific models, driven by advancements in technology and interdisciplinary research

***3. Recent Trends in Geomorphology***

Recent trends in geomorphology reflect advancements in technology, interdisciplinary approaches, and a growing emphasis on the interaction between human activities and geomorphic processes. Here's an overview of the most notable trends:

### 1. **Integration of Advanced Technology**

* **Remote Sensing and GIS**:
  + Satellite imagery, LiDAR, UAV (drone) mapping, and geographic information systems (GIS) are revolutionizing data collection and analysis.
  + High-resolution topographic data enables detailed studies of landscapes at multiple scales.
* **Numerical Modeling**:
  + Advanced computational models simulate geomorphic processes over time, from short-term events (e.g., floods) to long-term landscape evolution.
* **Machine Learning and Artificial Intelligence**:
  + These tools are increasingly applied to analyze large datasets, automate feature recognition, and predict geomorphic changes.

### 2. **Focus on Anthropogeomorphology**

* Geomorphology now considers the profound impact of human activities on landscapes, such as:
  + Urbanization and its effects on fluvial systems.
  + Mining, deforestation, and agricultural practices leading to soil erosion.
  + Climate change and its influence on geomorphic processes (e.g., glacial retreat, sea-level rise).
* The concept of the **Anthropocene** (human-dominated epoch) has sparked debates on how to integrate human-induced changes into geomorphological frameworks.

### 3. **Planetary Geomorphology**

* With space exploration, geomorphologists study landforms and processes on other planets (e.g., Mars, Venus, and the Moon).
* Analyses focus on comparing extraterrestrial features (e.g., Martian river channels) with Earth analogs to understand planetary evolution.

### 4. **Geomorphology and Climate Change**

* Investigating how global warming impacts geomorphic systems, such as:
  + Accelerated glacier and permafrost melting.
  + Shifts in sediment transport in rivers due to altered precipitation patterns.
  + Increased frequency of extreme events like landslides, floods, and coastal erosion.
* Developing models to predict future landscape responses under different climate scenarios.

### 5. **Interdisciplinary and Applied Geomorphology**

* **Eco-geomorphology**:
  + Exploring interactions between geomorphic processes and ecosystems, such as vegetation's role in stabilizing slopes or shaping river systems.
* **Sustainable Development**:
  + Geomorphological research informs infrastructure planning, hazard mitigation, and resource management.
* **Geoheritage and Geotourism**:
  + Promoting the conservation and appreciation of unique landforms and their geological significance.

### 6. **Quaternary and Holocene Geomorphology**

* Increasing focus on understanding landscapes' evolution during the Quaternary period, including glacial-interglacial cycles and Holocene climatic fluctuations.
* Use of dating techniques like radiocarbon dating, luminescence dating, and cosmogenic nuclide dating to reconstruct past environments.

### 7. **Geomorphological Hazards and Risk Assessment**

* Improved understanding of hazards like landslides, floods, tsunamis, and volcanic eruptions.
* Developing early warning systems and risk management strategies to reduce disaster impacts.

### 8. **Complexity and Nonlinear Dynamics**

* Recognizing landscapes as complex systems with feedback loops, thresholds, and nonlinear behaviors.
* Investigating how small changes (e.g., vegetation cover) can lead to significant geomorphic transformations (e.g., desertification).

### 9. **Citizen Science and Public Engagement**

* Crowdsourcing and citizen science initiatives, where non-specialists collect geomorphological data (e.g., river monitoring apps).
* Increased emphasis on educating the public about geomorphic processes and their societal relevance.

### 10. **Resilience and Restoration Geomorphology**

* Emphasizing restoring degraded landscapes, such as:
  + River restoration projects to reestablish natural flow regimes.
  + Coastal management to combat erosion and sea-level rise impacts.
* Applying geomorphic knowledge to enhance ecosystems' resilience to environmental changes.

These trends highlight the dynamic nature of geomorphology as a field that evolves alongside technological advancements, societal challenges, and the need for sustainable management of Earth systems. Let me know if you'd like more detail on any specific trend!

***4.Postmedern geomorphology***

Postmodern geomorphology refers to an approach within the study of landforms and Earth's surface processes that critiques and expands upon traditional, positivist views of geomorphology. It incorporates ideas from postmodern philosophy, emphasizing pluralism, subjectivity, and the role of social, cultural, and historical contexts in shaping our understanding of geomorphic phenomena.

### Key Aspects of Postmodern Geomorphology:

1. **Critique of Positivism**:
   * Traditional geomorphology often relies on positivist approaches, focusing on empirical observation and universal laws.
   * Postmodern geomorphology challenges the idea of objective "truth," suggesting that scientific knowledge is influenced by human values, biases, and societal norms.
2. **Emphasis on Multiple Perspectives**:
   * It acknowledges that landscapes can be understood differently depending on cultural, historical, or individual perspectives.
   * For example, indigenous interpretations of landforms often differ from those in Western scientific traditions.
3. **Focus on Context and Scale**:
   * Postmodern approaches emphasize the importance of context in understanding geomorphic processes.
   * It questions the transferability of concepts across different spatial and temporal scales.
4. **Interdisciplinary Connections**:
   * Postmodern geomorphology draws from other fields, such as sociology, history, and cultural studies, to provide a more comprehensive view of landscapes.
   * It also considers the interplay between human activities and natural processes.
5. **Narratives and Reflexivity**:
   * Geomorphologists in this approach reflect on their own role in shaping research and acknowledge that scientific narratives are constructed.

### Examples in Practice:

* Investigating how cultural narratives shape interpretations of natural hazards like landslides or floods.
* Examining the social implications of geomorphic research, such as its influence on land-use policies or resource management.
* Exploring the historical evolution of geomorphic theories and how they reflect the cultural contexts of their time.

### Criticism of Postmodern Geomorphology:

* Some argue that its relativist stance risks undermining the scientific rigor of geomorphology.
* The lack of emphasis on predictive capabilities may limit its practical applications.

By integrating postmodern perspectives, geomorphologists can enrich their understanding of landscapes, considering not just physical processes but also the broader societal and cultural dimensions. Would you like to explore specific applications or further theoretical details?

***5. Branches of Geomorphology and their significance.***

Geomorphology is the study of landforms and the processes that shape the Earth's surface. Over time, it has developed into several specialized branches, each focusing on different aspects of landform evolution, scale, and processes. Here’s an overview of the main branches of geomorphology and their significance:

### 1. **Physical Geomorphology**

**Definition**:- Physical geomorphology focuses on the physical processes that shape the Earth's surface, such as weathering, erosion, transportation, and deposition.

**Significance**:

* Helps understand how landforms evolve over time.
* Provides insight into natural hazards like floods, landslides, and coastal erosion.
* Crucial for environmental management, including flood control, land-use planning, and the conservation of soil and water resources.
* Important for studying the effects of climate change on landforms, such as glacial retreat or desertification.

### 2. **Historical Geomorphology**

**Definition**:- Historical geomorphology investigates the long-term development of landforms through geological time scales, focusing on the history of Earth’s surface changes.

**Significance**:

* Helps reconstruct past landscapes and understand the processes responsible for their formation.
* Provides a historical context for current environmental conditions and predicts future landscape changes.
* Useful in the study of tectonic, climatic, and sea-level changes, offering a deep time perspective on landscape evolution.

### 3. **Tectonic Geomorphology**

**Definition**:- Tectonic geomorphology examines the interaction between tectonic forces (such as plate movements, faulting, and folding) and surface processes to understand how landforms are shaped by tectonic activity.

**Significance**:

* Essential for understanding the role of tectonic forces in the formation of mountain ranges, earthquakes, and volcanic landforms.
* Helps in understanding the relationship between internal Earth dynamics and surface landscape features.
* Important in the study of fault zones and the seismic hazards that affect large populations.
* Crucial for the assessment of land stability, particularly in seismically active regions.

### 4. **Glacial Geomorphology**

**Definition**:- Glacial geomorphology studies the processes and landforms associated with glaciers, ice sheets, and ice caps, including the effects of glaciation on landscapes.

**Significance**:

* Key to understanding the formation of glacial landscapes like valleys, moraines, and fjords.
* Provides insight into past climate conditions during ice ages and the effects of glacial retreat.
* Important for understanding current changes in glacial environments due to global warming and sea-level rise.
* Helps in the management of water resources, as many rivers and lakes are fed by glacial meltwater.

### 5. **Fluvial Geomorphology**

**Definition**:-- Fluvial geomorphology focuses on river systems and the processes of erosion, sediment transport, and deposition that shape river channels, floodplains, and valleys.

**Significance**:

* Critical for understanding river dynamics and landform evolution such as meanders, oxbow lakes, and deltas.
* Key in flood risk assessment and management, helping to predict and mitigate the impacts of flooding.
* Important for water resource management, including dam construction, irrigation, and river navigation.
* Contributes to the understanding of sediment transport and river restoration.

### 6. **Coastal Geomorphology**

**Definition**:-- Coastal geomorphology investigates the processes that shape coastal landforms, such as waves, tides, currents, and longshore drift.

**Significance**:

* Vital for understanding coastal erosion, sediment transport, and the formation of features like beaches, cliffs, and sandbars.
* Essential for managing coastal habitats and addressing issues like beach erosion and rising sea levels.
* Crucial for urban planning in coastal areas and the development of infrastructure to withstand coastal hazards such as storms and flooding.
* Important for understanding and preserving coastal ecosystems, which provide significant ecological services.

### 7. **Karst Geomorphology**

**Definition**:-- Karst geomorphology focuses on landscapes shaped by the dissolution of soluble rocks like limestone, resulting in landforms such as caves, sinkholes, and underground rivers.

**Significance**:

* Helps understand the formation of unique karst features like stalactites, stalagmites, and extensive cave systems.
* Important for groundwater studies, as karst landscapes often form significant aquifers.
* Vital for understanding geohazards like sinkholes and land subsidence, especially in populated areas overlying karst terrain.
* Crucial for managing water resources and exploring the effects of human activity on karst systems.

### 8. **Applied Geomorphology**

**Definition**:-- Applied geomorphology focuses on the practical applications of geomorphic principles to solve real-world problems, particularly in environmental management and land-use planning.

**Significance**:

* Plays a key role in disaster risk management, including flood control, landslide prevention, and soil erosion management.
* Important for urban planning, agriculture, and infrastructure development, helping to assess land suitability and stability.
* Involves the study of human impacts on landforms and landscapes, including deforestation, mining, and urbanization, and offers solutions to mitigate these impacts.
* Supports sustainable development by considering environmental constraints and the long-term effects of land use.

### 9. **Pedogenic Geomorphology**

**Definition**:-- Pedogenic geomorphology explores the relationship between soil formation (pedogenesis) and landform development, particularly how soils interact with surface processes.

**Significance**:

* Essential for understanding the formation of different soil types and their distribution across landscapes.
* Important for agriculture, as soil properties influence crop production, irrigation, and land management.
* Contributes to studies on erosion and soil conservation by examining how soil forms and is modified by geomorphic processes.
* Vital for understanding the impact of climate and human activity on soil health and fertility.

### 10. **Paleogeomorphology**

**Definition**:-- Paleogeomorphology studies ancient landforms and the processes that shaped them during past geological periods.

**Significance**:

* Provides insights into Earth's historical climates, tectonic movements, and environmental conditions.
* Useful for reconstructing past landscapes, which can inform predictions about future geomorphic changes.
* Helps in understanding the evolution of ecosystems and the impact of ancient processes on present-day landscapes.

### Conclusion

The various branches of geomorphology contribute significantly to a broad understanding of Earth's surface processes and landforms. These specialized branches help to address environmental challenges, inform land-use planning, manage natural resources, and predict the impacts of climate change. Through their study, geomorphologists can contribute to the sustainable development and preservation of the Earth's landscapes

***6. Theoretical Geomorphology***

**Theoretical geomorphology** is a subfield of geomorphology that focuses on developing models, frameworks, and theories to understand the processes and dynamics that shape landforms over time. Unlike applied geomorphology, which focuses on real-world problems and practical applications, theoretical geomorphology seeks to explain the underlying principles and mechanisms that govern landscape evolution.

Theoretical geomorphology involves the use of mathematical models, concepts from physics and biology, and computational simulations to develop general theories about geomorphic processes. It aims to predict how landforms will evolve under different environmental conditions and how various geomorphic processes interact.

### **Key Concepts in Theoretical Geomorphology**

1. **Process-Form Relationship**
   * The fundamental idea in theoretical geomorphology is understanding how **geomorphic processes** (such as erosion, deposition, and weathering) give rise to **landforms**.
   * Geomorphologists seek to develop generalized models that can predict how certain processes will create or modify specific landforms under varying conditions.
2. **Dynamic Equilibrium**
   * A major concept in theoretical geomorphology is the idea of **dynamic equilibrium** (introduced by John Hack), where landforms evolve over time but maintain a stable state due to the balance between processes like erosion and deposition.
   * In this context, landforms are seen as adjusting to external forces (such as tectonics or climate) in a way that maintains stability over long periods, despite ongoing changes.
3. **Landform Evolution Models**
   * Theoretical geomorphology develops mathematical models to explain the evolution of landforms over time.
     + Example: The **stream erosion model**, which describes how a river erodes its channel and how its shape evolves as a result of sediment transport and water flow.
     + The **weathering-front model** in hillslope processes describes how the depth and movement of weathering fronts affect the landscape.
4. **Thresholds and Nonlinear Processes**
   * Geomorphologists recognize that many geomorphic processes are nonlinear, meaning that small changes in environmental conditions can lead to large, sometimes abrupt changes in landforms.
   * This concept is particularly important in areas like **landslide dynamics** and **fluvial system behavior**, where tipping points or thresholds can dramatically alter landscape features.
5. **Feedback Mechanisms**
   * Feedback mechanisms are a critical aspect of theoretical geomorphology, explaining how changes in one part of the system can influence other parts of the system, either amplifying or dampening the effects of change.
     + **Positive feedback**: A process that enhances or amplifies a change (e.g., erosion increasing steepness, which leads to more erosion).
     + **Negative feedback**: A process that counteracts or stabilizes a change (e.g., reduced erosion due to deposition, which flattens a landscape).
6. **Scale and Hierarchy**
   * Theoretical geomorphology examines how processes operate at different spatial and temporal scales, from micro-scale (e.g., individual grain movement) to macro-scale (e.g., mountain-building processes over millions of years).
   * This helps in understanding how local processes (like river meandering) fit into larger, regional-scale processes (like plate tectonics or climate patterns).

### **Significance of Theoretical Geomorphology**

1. **Understanding Landform Development**
   * Theoretical geomorphology provides a framework for understanding how landscapes evolve through time. By developing models, geomorphologists can predict the evolution of landforms under different conditions, such as climate change, tectonic shifts, or human impact.
2. **Predicting Future Changes**
   * It allows for better prediction of landscape changes based on environmental changes. For example, how rising sea levels might reshape coastal landforms or how increased precipitation might affect river channel morphology.
3. **Informing Environmental Management**
   * Theoretical models help inform land-use planning and management. By understanding the processes that shape landforms, it’s easier to manage erosion, floods, and other environmental hazards, even in the absence of direct observation.
4. **Improving Resource Management**
   * It aids in resource management, such as predicting how water and sediment flow through a landscape, which is critical for managing water resources, agriculture, and flood control.
5. **Interdisciplinary Integration**
   * Theoretical geomorphology interacts with fields such as **climatology**, **ecology**, and **geophysics**, helping integrate knowledge across disciplines. This is crucial for understanding complex systems like **climate change** and its effects on landscapes or ecosystems.

### **Historical Development of Theoretical Geomorphology**

1. **Early Developments**:
   * Theoretical geomorphology has roots in the ideas of early geologists like **James Hutton** (who proposed uniformitarianism) and **William Morris Davis**, who created the **cycle of erosion** model, which explained landform evolution through stages of youth, maturity, and old age.
2. **Mid-20th Century**:
   * In the mid-20th century, geomorphologists like **John Hack** and **Luna Leopold** expanded the idea of equilibrium and dynamic systems, focusing on **landform evolution** and how processes maintain a balance between forces like uplift and erosion.
3. **Modern Theories**:
   * More recently, the field has become increasingly quantitative and process-oriented, with the development of **mathematical models**, **computer simulations**, and **remote sensing techniques**. Models have been developed for specific landforms like rivers, hillslopes, glaciers, and coastal environments.
4. **Recent Trends**:
   * There is growing emphasis on **nonlinear dynamics**, **complex systems**, and **multiscale modeling** to better understand the intricate relationships between landform processes across different spatial and temporal scales.

### **Applications of Theoretical Geomorphology**

1. **Landscape Evolution Modeling**:
   * Developing predictive models of landscape evolution under various conditions such as climate change, tectonic activity, or land-use changes.
2. **Hazard Prediction**:
   * Theoretical geomorphology helps predict natural hazards like floods, landslides, and coastal erosion, which is crucial for disaster risk management.
3. **Environmental Restoration**:
   * Theoretical models inform efforts to restore or rehabilitate degraded landscapes (e.g., river channel restoration or hillslope stabilization) by understanding the processes that originally shaped those environments.
4. **Climate Change Studies**:
   * Models of landform evolution are increasingly applied to understand how climate change impacts landforms, including glacier retreat, sea-level rise, and shifts in river systems

### **Conclusion**

Theoretical geomorphology is fundamental in explaining the complex processes that shape the Earth's surface. By developing abstract models and theories, geomorphologists can understand and predict the dynamic behavior of landforms, contributing to environmental management, hazard prediction, and landscape restoration. The field continues to evolve with advancements in technology and computational methods, providing a deeper understanding of landscape dynamics across time and space.

***7. Applied Geomorphology***

**Applied geomorphology** is a branch of geomorphology that focuses on the practical application of geomorphic knowledge to address real-world challenges. It bridges theoretical geomorphology with societal needs, offering insights into landform processes and their interactions with human activities, which are essential for sustainable development, environmental management, and hazard mitigation.

### Key Areas of Applied Geomorphology

#### 1. **Hazard Assessment and Risk Management**

* **Landslides and Slope Stability**:
  + Identifying areas prone to landslides or erosion to guide infrastructure planning and mitigate risks.
  + Using geomorphic data to design slope stabilization measures.
* **Flood Risk Mapping**:
  + Analyzing river dynamics and floodplain morphology to predict flood-prone areas.
  + Informing flood control measures such as levees, reservoirs, and zoning laws.
* **Coastal Hazards**:
  + Studying erosion, storm surges, and tsunamis to protect coastal communities.
  + Designing shoreline protection structures like seawalls and breakwaters.

#### 2. **Urban Planning and Infrastructure Development**

* **Site Selection and Terrain Evaluation**:
  + Assessing geomorphic features to choose suitable locations for urban expansion, roads, bridges, and dams.
* **Soil Erosion Control**:
  + Developing strategies to prevent erosion during and after construction activities.
* **Groundwater and Drainage Management**:
  + Understanding karst geomorphology and alluvial systems to manage water resources and prevent subsidence.

#### 3. **Environmental Management**

* **Land Degradation and Desertification**:
  + Monitoring and mitigating processes like deforestation, overgrazing, and soil erosion.
* **Restoration of Degraded Landscapes**:
  + Applying geomorphic principles to restore natural landforms, such as recontouring land in mining areas or reforestation in eroded regions.
* **Wetland and River Restoration**:
  + Rehabilitating river systems to improve biodiversity, water quality, and flood resilience.

#### 4. **Climate Change Adaptation**

* **Sea-Level Rise**:
  + Assessing the vulnerability of coastal geomorphic systems and communities.
  + Designing adaptive strategies such as managed retreat or artificial dune creation.
* **Glacial and Permafrost Retreat**:
  + Monitoring geomorphic changes in high-altitude and polar regions to predict impacts on ecosystems and infrastructure.

#### 5. **Resource Management**

* **Mining and Quarrying**:
  + Evaluating landforms to locate resources like minerals, aggregates, and fossil fuels.
  + Managing geomorphic impacts of extraction activities, including tailings and surface reclamation.
* **Water Resources**:
  + Assessing river and aquifer dynamics for sustainable water use.

#### 6. **Cultural and Geoheritage Conservation**

* **Protection of Geomorphological Sites**:
  + Preserving unique landforms of scientific, cultural, or aesthetic significance.
* **Geotourism**:
  + Promoting the sustainable use of geomorphic landscapes for education and tourism (e.g., canyons, caves, and volcanic landscapes).

#### 7. **Agricultural Development**

* **Soil Conservation**:
  + Implementing measures to reduce erosion and enhance soil fertility on sloped terrain.
* **Terrace Farming and Land Reclamation**:
  + Designing terraces to make steep landscapes suitable for agriculture.

#### 8. **Military and Strategic Applications**

* Understanding terrain for defense strategies, navigation, and the location of facilities in relation to landform stability and accessibility.

### Techniques in Applied Geomorphology

* **Remote Sensing and GIS**:
  + Mapping and analyzing landforms to predict hazards or plan development projects.
* **Field Surveys**:
  + Ground truthing to validate geomorphic models and assess local conditions.
* **Modeling and Simulation**:
  + Using computational tools to predict geomorphic changes under different scenarios.

### Case Studies in Applied Geomorphology

1. **Three Gorges Dam, China**:
   * Geomorphic studies informed the dam's design and its impact on river sedimentation and erosion.
2. **Coastal Management in the Netherlands**:
   * Applied geomorphic principles to develop innovative solutions like the Sand Motor to combat coastal erosion.
3. **Landslide Risk Mapping in the Himalayas**:
   * Identifying unstable slopes to guide road construction and settlement planning.

Applied geomorphology demonstrates the field's importance in solving practical problems, ensuring sustainable use of Earth's resources, and mitigating environmental challenges. Would you like more details on specific applications or methods?

Bottom of Form

***8. Structural Geomorphology***

Structural geomorphology is a branch of geomorphology that studies the influence of geological structures (such as faults, folds, fractures, and rock types) on the development and appearance of landforms. This discipline bridges geology and geomorphology by exploring how the Earth's structural features shape landscapes and how those landscapes evolve over time due to processes like erosion, weathering, and tectonic activity.

### Key Concepts in Structural Geomorphology

1. **Tectonic Structures**:
   * **Faults**: Cracks along which rocks have moved, influencing features like fault scarps, rift valleys, and horst-and-graben structures.
   * **Folds**: Bending of rock layers resulting in anticlines, synclines, and domes, which can control drainage patterns and landscape forms.
2. **Rock Type and Strength**:
   * Different rocks have varying resistance to erosion, leading to differential erosion and the formation of features like ridges (hard rocks) and valleys (soft rocks).
3. **Tectonic Landforms**:
   * Landforms directly created by tectonic activity, such as mountain ranges, plateaus, and basins.
4. **Drainage Patterns**:
   * Patterns of rivers and streams often reflect underlying structural controls. Examples include:
     + **Dendritic** (typical in uniform material),
     + **Trellis** (controlled by folded or faulted rocks),
     + **Radial** (around domes or volcanic cones).
5. **Geomorphic Processes**:
   * Interaction between tectonic uplift and erosional processes, which shapes landscapes over geological timescales.

### Examples of Structural Geomorphology Features

* **Himalayas**: Formed by the collision of tectonic plates.
* **Grand Canyon**: Exposes layered rock structures, influenced by faulting and erosion.
* **Great Rift Valley**: Created by extensional tectonics.
* **Appalachian Mountains**: Show the influence of folding and erosion on landscape development.

### Applications

* Understanding landscape evolution.
* Assessing geological hazards like landslides and earthquakes.
* Informing resource exploration, such as identifying reservoirs in folded or faulted terrains.

As a geography student, this field provides a great opportunity to integrate geological principles with spatial analysis! If you'd like, I can recommend further reading or help with specific concepts or case studies.

Bottom of Form

***9. Fluvial Geomorphology***

Fluvial geomorphology is the study of how rivers shape the Earth's surface. It examines the processes, forms, and interactions involved in river systems, focusing on how water, sediment, and landscapes interact over time. This field integrates aspects of geology, hydrology, and physical geography, making it crucial for understanding both natural landscapes and human-environment interactions.

### Key Concepts in Fluvial Geomorphology:

1. **Fluvial Processes**:
   * **Erosion**: Rivers erode their beds and banks through processes like hydraulic action, abrasion, attrition, and solution.
   * **Transportation**: Sediments are transported by rivers in solution (dissolved load), suspension (suspended load), saltation (bouncing), and traction (rolling along the riverbed).
   * **Deposition**: Occurs when the river loses energy, leading to the settlement of transported materials.
2. **River Features**:
   * **Upper Course**: Characterized by steep gradients, V-shaped valleys, waterfalls, and rapids.
   * **Middle Course**: Features meanders, wider valleys, and floodplains as the gradient decreases.
   * **Lower Course**: Includes features like deltas, levees, and estuaries, where sediment deposition dominates.
3. **Fluvial Landforms**:
   * **Erosional**: Includes waterfalls, gorges, river cliffs, and interlocking spurs.
   * **Depositional**: Examples are point bars, oxbow lakes, floodplains, and deltas.
4. **River Dynamics**:
   * **Discharge**: The volume of water flowing through a river channel.
   * **Sediment Load**: The amount and size of material carried by the river.
   * **Channel Morphology**: The shape and structure of the river channel, influenced by factors like gradient and sediment type.
5. **Human Impacts**:
   * Urbanization, agriculture, and dam construction significantly alter river systems, affecting sediment transport, flow regimes, and ecosystem health.
6. **Application of Fluvial Geomorphology**:
   * Managing river systems for flood control and water resources.
   * Restoration of degraded river environments.
   * Predicting and mitigating the impacts of climate change on rivers.

***10. Glacial Geomorphology***

Glacial geomorphology is the study of how glaciers shape the Earth's surface, focusing on the processes, landforms, and sediments associated with glaciers and ice sheets. It plays a vital role in understanding past climates (paleoclimatology), current landscape evolution, and the impacts of glacial processes on ecosystems and human activity.

### Key Concepts in Glacial Geomorphology:

#### 1. **Glacial Processes**:

* **Erosion**: Glaciers erode the landscape through:
  + **Abrasion**: Rocks and sediments frozen in the glacier scrape and grind against the underlying rock.
  + **Plucking**: Glacier ice pulls away pieces of rock from the ground.
  + **Freeze-thaw weathering**: Repeated freezing and thawing of water in cracks breaks down rocks.
* **Transportation**: Glaciers transport sediment as:
  + **Supraglacial debris**: Material on the glacier surface.
  + **Englacial debris**: Material within the glacier.
  + **Subglacial debris**: Material carried at the glacier base.
* **Deposition**: When glaciers retreat or lose energy, they deposit sediments, creating unique landforms.

#### 2. **Glacial Landforms**:

**Erosional Landforms**:

* **Cirques**: Bowl-shaped hollows formed by glacial erosion, often hosting tarns (small lakes).
* **Arêtes and Pyramidal Peaks**: Sharp ridges and pointed summits formed by intersecting cirques.
* **U-shaped Valleys**: Formed by glacier movement, contrasting with the V-shaped valleys of rivers.
* **Hanging Valleys**: Smaller glacial valleys that intersect a main valley at a higher elevation.
* **Roche Moutonnées**: Asymmetrical rock formations shaped by glacial abrasion and plucking.

**Depositional Landforms**:

* **Moraines**: Ridges of debris deposited by glaciers, classified as lateral, medial, terminal, or ground moraines.
* **Drumlins**: Streamlined, elongated hills formed under the glacier.
* **Eskers**: Sinuous ridges of sediment deposited by meltwater streams beneath glaciers.
* **Kames**: Mounds of sediment deposited by melting ice.
* **Outwash Plains**: Areas of sediment spread by meltwater beyond the glacier's terminus.

#### 3. **Types of Glaciers**:

* **Valley Glaciers**: Found in mountain regions, confined to valleys.
* **Ice Sheets**: Massive glaciers covering large areas, like those in Antarctica and Greenland.
* **Piedmont Glaciers**: Formed when valley glaciers spread out onto flat plains.
* **Ice Caps**: Smaller versions of ice sheets covering mountain ranges or plateaus.

#### 4. **Glacial Sediments**:

* **Till**: Unsorted debris deposited directly by glacier ice.
* **Glaciofluvial Deposits**: Sorted sediments transported by meltwater, including sands and gravels.
* **Erratics**: Large boulders transported and deposited far from their origin.

#### 5. **Glacial-Climate Interaction**:

* Glaciers act as sensitive indicators of climate change.
* Evidence of past glaciations, such as moraines and erratics, helps reconstruct paleoclimate conditions.

#### 6. **Human and Environmental Impacts**:

* Glacial retreat due to global warming affects water supply, sea levels, and ecosystems.
* Landforms like U-shaped valleys and fjords influence tourism and settlement patterns.

If you're studying glacial geomorphology, are you focusing on past glaciations, specific landforms, or contemporary issues like glacial retreat?

***11. Arid Geomorphology***

Arid geomorphology is the study of landscapes and landforms in arid (dry) and semi-arid environments, where limited precipitation and high evaporation rates dominate the shaping of the terrain. These regions, often referred to as deserts, are influenced by unique processes that result in distinctive geomorphological features.

### Key Characteristics of Arid Environments:

1. **Climate**:
   * Low precipitation (usually less than 250 mm annually).
   * High evaporation rates and large temperature fluctuations.
   * Sparse vegetation cover.
2. **Dominant Processes**:
   * Wind action (aeolian processes).
   * Occasional but intense rainfall, leading to fluvial processes.
   * Weathering, particularly mechanical weathering, due to temperature extremes.

### Key Concepts in Arid Geomorphology:

#### 1. **Aeolian Processes**:

* **Erosion**: Wind erodes surfaces through:
  + **Deflation**: Removal of loose, fine particles.
  + **Abrasion**: Sand and particles carried by wind polish or erode rock surfaces.
* **Transportation**: Wind transports material via:
  + **Suspension**: Fine particles carried in the air.
  + **Saltation**: Sand grains bouncing along the ground.
  + **Creep**: Larger particles rolling or sliding along the surface.
* **Deposition**: Leads to the formation of:
  + Sand dunes (e.g., barchan, transverse, longitudinal, star dunes).
  + Loess deposits (fine silt and clay transported and deposited by wind).

#### 2. **Fluvial Processes**:

* Though infrequent, episodic heavy rainfall creates:
  + **Flash floods**: Short-lived but intense flows of water.
  + **Arroyos/Wadis**: Dry riverbeds that temporarily fill during rain events.
  + **Alluvial Fans**: Cone-shaped deposits of sediment at the base of steep slopes.
  + **Bajada**: A broad slope formed by the coalescence of several alluvial fans.

#### 3. **Weathering**:

* **Mechanical Weathering**: Dominates due to lack of moisture, including:
  + **Thermal stress**: Expansion and contraction of rock due to temperature changes.
  + **Salt crystallization**: Growth of salt crystals in rock pores causes disintegration.
* **Chemical Weathering**: Limited but occurs where moisture is present (e.g., in oases).

#### 4. **Landforms**:

**Erosional Landforms**:

* **Yardangs**: Streamlined ridges carved by wind erosion.
* **Ventifacts**: Rocks shaped and polished by wind abrasion.
* **Pediments**: Gently sloping rock surfaces extending from mountain bases.
* **Inselbergs**: Isolated rock hills rising abruptly from flat plains.
* **Desert Pavement**: Surfaces covered with closely packed pebbles after finer particles are removed.

**Depositional Landforms**:

* **Sand Dunes**: Formed by wind deposition of sand.
* **Playa Lakes**: Temporary lakes in desert basins that dry up, leaving salt flats or clay pans.
* **Loess Plains**: Extensive deposits of windblown silt.

#### 5. **Human and Ecological Interactions**:

* Desertification: Expansion of desert-like conditions into semi-arid areas due to climate change and human activities.
* Oases: Habitats in deserts with sufficient water to support life.
* Wind erosion control: Planting vegetation and creating barriers to stabilize soil.

### Application of Arid Geomorphology:

* Understanding past climate changes through desert landforms and sediments.
* Managing and mitigating desertification in semi-arid regions.
* Developing strategies for sustainable living in desert environments.

***12. Environmental Geomorphology***

Environmental geomorphology is a subfield of geomorphology that focuses on the interaction between geomorphic processes and human activity. It studies how natural landscapes are shaped and modified over time, as well as how these changes affect and are influenced by environmental and human systems. The goal of environmental geomorphology is to understand the balance between natural processes and anthropogenic impacts to aid in sustainable land use, environmental management, and disaster mitigation.

### Key Concepts in Environmental Geomorphology:

1. **Natural Processes**:
   * Weathering, erosion, sediment transport, and deposition.
   * River systems, coastal dynamics, glacial processes, and aeolian (wind-driven) geomorphology.
2. **Human Impacts**:
   * Urbanization and infrastructure development altering natural landscapes.
   * Deforestation, agriculture, and mining causing soil erosion and land degradation.
   * Climate change influencing geomorphic processes, such as glacier retreat and sea level rise.
3. **Applied Aspects**:
   * **Hazard Assessment**: Understanding risks like landslides, floods, and desertification to prevent or mitigate disasters.
   * **Land Management**: Planning sustainable land use by considering soil stability, erosion control, and water management.
   * **Restoration**: Rehabilitating degraded landscapes, such as reforestation or reconstructing riverbanks.
4. **Climate and Geomorphology**:
   * Examining how climate change modifies geomorphic systems (e.g., increased erosion from intense storms or changes in sediment flow in rivers).
5. **Tools and Techniques**:
   * Remote sensing and GIS (Geographic Information Systems) for mapping and analyzing landforms.
   * Field surveys for on-the-ground data collection.
   * Computer modeling to simulate geomorphic processes and predict changes.
6. **Interdisciplinary Connections**:
   * Links to ecology, hydrology, and environmental science for a holistic understanding of landscape dynamics.

### Applications:

* Urban planning: Minimizing construction in floodplains or landslide-prone areas.
* Conservation: Protecting natural habitats by maintaining geomorphic stability.
* Climate adaptation: Designing strategies for rising sea levels and altered river systems.

***13. Paleogeomorphology***

Paleogeomorphology is the study of ancient landforms and landscapes, focusing on how they were shaped by past geological and geomorphological processes. By examining these ancient features, paleogeomorphology provides insights into the Earth's history, including past climates, tectonic activity, and erosion patterns. It is an essential field for understanding long-term landscape evolution and for reconstructing paleoenvironments.

### Key Concepts in Paleogeomorphology:

1. **Ancient Landforms**:
   * Fossilized river valleys, glacial features, and shorelines.
   * Paleosols (ancient soils) that indicate past climates and vegetation.
   * Submerged or buried landscapes, such as those preserved beneath sedimentary layers.
2. **Processes Studied**:
   * Tectonic uplift and subsidence.
   * Erosion and deposition under different climatic conditions.
   * Volcanic activity and its influence on landscape formation.
3. **Tools and Methods**:
   * **Stratigraphy**: Analyzing sedimentary layers to determine the age and conditions under which landscapes formed.
   * **Geochronology**: Using radiometric dating (e.g., carbon dating, uranium-lead dating) to date ancient landforms.
   * **Remote Sensing**: Satellite imagery and LiDAR to detect buried or hidden geomorphic features.
   * **Paleontological Evidence**: Fossils that provide context for environmental conditions and geomorphic processes.
4. **Applications**:
   * **Oil and Gas Exploration**: Understanding paleochannels and sedimentary basins helps locate reservoirs.
   * **Mineral Exploration**: Ancient landscapes can indicate the presence of mineral deposits.
   * **Reconstructing Past Climates**: Studying features like glacial moraines or desert dunes reveals information about ancient climates.
   * **Sea-Level Changes**: Analyzing old shorelines and marine terraces helps reconstruct historical sea levels.
5. **Connections to Other Fields**:
   * **Quaternary Geology**: Overlaps in studying recent geological history.
   * **Geomorphology and Geology**: Links between surface processes and subsurface structures.
   * **Paleoclimatology**: Provides climate context for geomorphic features.
6. **Challenges**:
   * Preserving evidence: Many ancient landforms are eroded or modified over time.
   * Interpretation difficulties: Determining the exact processes and timelines can be complex, requiring multidisciplinary approaches.

### Examples of Paleogeomorphic Features:

* Ancient river systems preserved in sedimentary basins.
* Fossilized sand dunes (e.g., Navajo Sandstone in the USA).
* Glacial striations and moraines from past ice ages.
* Submerged landscapes, such as Doggerland in the North Sea, which was once above sea level.

***14.*** *Interior Structure of the Earth*

## 

The earth is divided into three main layers. They are-(i) crust, (ii) mantle and (iii)core.

**The Earth’s Crust:-**

**Definition-** Crust refers to the outer most portion of the earth, lying above the Moho. The thickness of the crust is about 8-40 km and it is made up of mostly igneous and sedimentary racks. It comprise two layers the upper discontinuous sial and the lower continuous sima. The densities of the crustal material are generally in the range of 2.5 to 3.3 g/cm2.

***15. Composition of the Earth***

**Composition of the earth crust-** The Earth’s crust is composed of eight most abundant elements. There quantities are given below in terms of percentage. Oxygen- 47%, Silican- 28%, Aluminum-8.1%, Iron-5%, Calcium-3.6%, Sodium- 2.8%, Patassium-2.6, Megnesium02,1%, Other-.8%. Oxygen is the predominant element, account a little less than half of the total weight. Second is silicon, which accounts for a little more than a quarter. Together they account for 75 percent of the crust by weight.

Aluminum accounts approximately 8 percent and iron for about 5 percent of the earth’s crust. These metals are very important to our industrial civilization. Four other metallic elements are- calcium, sodium, potassium and Magnesium. These four metallic elements are accounting 12 per cent of the crust. These elements are essential nutrients for plants and animal life. They determine of soil fertility.

Of the remaining chemical elements composition the Earth’s crust are very empowering the cycles of the solid earth. They are in radioactive forms.

**Structure of the Earth’s Crust:-** In accordance with the complexity of geophysical, geochemical and geological data, there are two basic types of earth’s crust- (i) Continental and (ii) Oceanic.

**Continental earth’s crust** - Continents cover roughly about one-third of the earth surface. They are mostly concentrated in the Northern Hemisphere. The thickness of the continental crust is from 30 to 50 km. Beneath the crust, there is a thin layer known as Moho. The average depth of Moho is about 35 km. The thickness of the continental crust is not same in everywhere. It is high beneath mountain ranges and low beneath the ocean basin. The density of the continental crust is ranging from 2.5 to 2.7g/cm3. From studies of earthquake waves, geologist have concluded that the continental crust consist of two continuous zones (i) lower and (ii) upper zone. The lower zone is continuous zones of mafic, compose of basalt and grabo, which is more dense. The upper continuous zone consists of felsic (granatic) rock, which is less dense, because the felsic portion has a chemical composition.

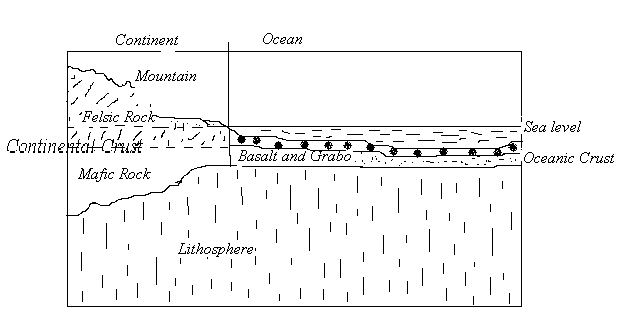
In terms of basic geological character, the continental crust can be divided into two types of regions creations and organic belts. Cratons are extensive fate stable regions of the continents in which complex crystalline rocks are exposed or buried beneath a relatively thin sedimentary cover. These regions have not been affected by any Earth movements for over a half million years. The shields are a regional surface of low relief having an elevation within a few hundred meters above sea level. Shields are broadly convex and relatively immobile regions usually constructed of Precambrian metamorphic and igneous rocks.

**Oceanic earth crust-** The oceanic earth crust s approximately 5 to 12 km. thick and has an average density of 3.0 g/cm3. This crust is mainly composed of basalt and grabo. The most important characteristic is its remarkable uniformity. The oceanic crust has three different layers, viz- upper, middle and lower. Upper layer is consists of calcareous and siliceous shells of microscopic marine organisms together with red clay. The middle layer consists of basaltic flows. It is 1 to 2.5 km thick. The lower layer consists of coarse-grained gabro.

***16. Earth Crust and Interior***

**THE CRUST:-** The crust is much thinner than any of the other layers, and is composed of the least dense calcium (Ca) and sodium (Na) aluminum-silicate minerals. Being relatively cold, the crust is rocky and brittle, so it can fracture in earthquakes. The shell of the earth, the crust, can be said to have two different thicknesses. Under the oceans, it is relatively thin. It varies in thickness from 5 to 8 km. Under the land masses, it is relatively thick. The thickness of the continental crust varies from 10 to 65 km. The eggshell analogy for the crust is not an exaggeration. It is paper thin compared with the radius of the earth which is approximately 6400 km. The total weight of the continental crust is less than 0.3% of the weight of the earth. Variations in the crust thickness are compensated by the weight of the water and the differences in the specific gravities of the crust under the oceans (3.0 to 3.1) and under the continents (2.7 to 2.8). If one thinks of the crust as virtually floating on the mantle, one is less likely to wonder why the earth does not wobble as it rotates about its axis. The weight of the crust plus the mantle has a reasonably uniform distribution over the globe.

**THE MOHO:-** The Moho, or the Mohorovicic Discontinuity, refers to a zone or a thin shell below the crust of the earth that varies in thickness from 1 to 3 km. In **seismology**, the term "***discontinuity***" is used in its general sense. It refers to a change over a short distance of a material property. In this case, the "short distance" may be as long as 3 km, a trifle compared with the radius of the earth. In that zone, the P-wave velocity has been observed to increase from approximately 6 to approximately 8 km/sec. The Moho is considered to be the boundary between the crust and the mantle. The increase in P-wave velocity is ascribed to change in composition of the medium. Rocks of the mantle are poorer in silicon but richer in iron and magnesium.

**THE MANTLE:-** The mantle can be thought of having three different layers. The separation is made because of different deformational properties in the mantle inferred from seismic wave measurements.

**(1) The upper layer is stiff:-** It is presumed that if the entire mantle had been as stiff, the outer shell of the earth would stay put. This stiff layer of the mantle and the overlying crust are referred to as the lithosphere. The lithosphere is approximately 80-km thick

(2) Beneath the lithosphere is a soft layer of mantle called the asthenosphere. Its thickness is inferred to be several times that of the lithosphere. One may think of this as a film of lubricant although film is not exactly the word for something so thick. It is assumed that the lithosphere, protruding (meaning: extending beyond) parts and all, can glide over the asthenosphere with little distortion of the lithosphere

(3) The mesosphere is the lowest layer of the mantle. Considering the vagueness in defining the lower boundary of the asthenosphere it would be expected that the thickness and material properties of the mesosphere are not well known. It is expected to have a stiffness somewhere between those of the lithosphere and the asthenosphere.

**THE CORE:-** It is known that the pressure increases toward the center of the earth. So does the temperature. The liquid outer layer versus the solid inner layer is rationalized by recognizing that the melting point of the material increases (with pressure) at a faster rate than the temperature as the center of the earth is approached. The core is composed mostly of iron (Fe) and is so hot that the outer core is molten, with about 10% sulphur (S). The inner core is under such extreme pressure that it remains solid.

***17. Rocks and Minarals***

**What is rock? write the different types of rock**

In geology, a **rock** is a naturally occurring solid composed of one or more minerals, mineraloids, or organic materials. Rocks form the Earth's crust and provide valuable insights into the Earth's history and processes.

### **Types of Rocks--** Rocks are classified into three main types based on their formation processes:

1. **Igneous Rocks**
   * Formed by the cooling and solidification of magma or lava.
   * Examples:
     + **Intrusive (Plutonic)**: Formed inside the Earth, with large crystals (e.g., granite, diorite).
     + **Extrusive (Volcanic)**: Formed on the Earth's surface, often with fine-grained textures (e.g., basalt, pumice).
2. **Sedimentary Rocks**
   * Formed from the accumulation, compaction, and cementation of sediments (particles of rocks, minerals, or organic material).
   * Often have layers and may contain fossils.
   * Types:
     + **Clastic**: Made from fragments of other rocks (e.g., sandstone, shale).
     + **Chemical**: Precipitated from solution (e.g., limestone, halite).
     + **Organic**: From accumulated biological material (e.g., coal, chalk).
3. **Metamorphic Rocks**
   * Formed when existing rocks are subjected to heat, pressure, or chemically active fluids, leading to physical or chemical changes.
   * Examples:
     + **Foliated**: Have a banded or layered appearance due to pressure (e.g., schist, gneiss).
     + **Non-foliated**: Lack a distinct layering (e.g., marble, quartzite).

Each rock type plays a role in the **rock cycle**, continuously transforming between these categories over geological time due to Earth's dynamic processes.

***18. What is minerals? write different types of minerals with example*.**

A **mineral** is a naturally occurring, inorganic solid with a definite chemical composition and an ordered atomic structure. Minerals are the building blocks of rocks and are essential to Earth's crust and processes.

### Characteristics of Minerals

1. **Naturally Occurring**: Formed through natural processes.
2. **Inorganic**: Not derived from living organisms.
3. **Solid**: Maintain a stable shape and volume.
4. **Definite Chemical Composition**: Have specific chemical formulas.
5. **Crystalline Structure**: Atoms are arranged in a specific, repeating pattern.

### **Types of Minerals:** Minerals are broadly classified based on their chemical composition. Here are the main types:

1. **Silicates-** Composed of silicon and oxygen, often with other elements. Most abundant group of minerals in Earth's crust. Examples: Quartz (SiO₂), Feldspar, Mica, Olivine.
2. **Carbonates--** Contain carbonate ions (CO₃²⁻). Often formed in sedimentary environments. Examples: Calcite (CaCO₃), Dolomite.
3. **Oxides-**- Composed of oxygen and one or more metal elements. Often economically valuable as ores. Examples: Hematite (Fe₂O₃), Magnetite (Fe₃O₄).
4. **Sulfides---** Contain sulfur combined with metals. Commonly found in ore deposits. Examples: Pyrite (FeS₂), Galena (PbS).
5. **Sulfates-** Contain sulfate ions (SO₄²⁻). Typically form through evaporation processes. Examples: Gypsum (CaSO₄·2H₂O), Barite.
6. **Halides-** Contain halogen ions (e.g., Cl⁻, F⁻) combined with metals. Examples: Halite (NaCl), Fluorite (CaF₂).
7. **Native Elements-** Consist of a single element. Examples: Gold (Au), Silver (Ag), Copper (Cu), Diamond (C).
8. **Phosphates-** Contain phosphate ions (PO₄³⁻). Often important for biological and industrial uses. Example: Apatite (Ca₅(PO₄)₃(F,Cl,OH)).

### **Importance of Minerals**

* **Economic Use**: Mining of metallic and non-metallic minerals.
* **Industrial Applications**: Used in construction, manufacturing, and technology.
* **Nutritional Needs**: Essential for health (e.g., calcium, iron, potassium).
* **Scientific Studies**: Provide clues about Earth's formation and processes.

***19. System Concept in Geomorphology***

Q. Write about the system concept in Geomorphology.

The **system concept** in geomorphology refers to the framework for understanding and analyzing the Earth's surface features and processes as interconnected systems. It emphasizes the relationships between landforms, the processes shaping them, and the factors influencing those processes. This approach allows geomorphologists to study landscapes holistically and predict how changes in one part of the system might affect others.

### **Key Components of a Geomorphic System**

**1.Inputs--** Energy sources (e.g., solar radiation, gravity). Materials such as sediment, water, and gases.

**2. Processes--** Mechanisms that transform inputs into outputs, such as erosion, weathering, transport, and deposition.

**3. Outputs--** Results of geomorphic processes, such as sediment deposition, altered landforms, or energy dissipation.

4. **Feedback Mechanisms**

* + **Positive Feedback**: Enhances or amplifies a process (e.g., increased erosion due to deforestation).
  + **Negative Feedback**: Stabilizes the system by counteracting changes (e.g., vegetation growth reducing erosion).

**6.Controls and Thresholds**

* 1. **Controls**: Factors influencing the system, such as climate, tectonics, and human activity.
  2. **Thresholds**: Critical limits that, when crossed, lead to significant changes in the system (e.g., landslides triggered by rainfall intensity).

### **Types of Geomorphic Systems**

**Open Systems--** Exchange energy and materials with their surroundings. Most geomorphic systems, like river systems, are open.

**Closed Systems---** No exchange of materials; only energy flows across the boundaries. Rare in nature but used in theoretical models.

### **Applications of the System Concept in Geomorphology**

1. **Dynamic Equilibrium—**Landscapes often seek a balance between forces shaping them and resisting forces. This state, called dynamic equilibrium, is maintained through continuous adjustments.
2. **Morphological Systems---** Focus on the form and structure of landforms, such as river valleys or sand dunes.
3. **Cascading Systems-**-- Emphasize the movement of materials and energy through a system, like sediment transport in a river.
4. **Process-Response Systems---** Explore the interactions between geomorphic processes and landforms, considering both the cause (process) and effect (response).

### **Example: River Systems**

A river system can be understood as a geomorphic system:

* **Inputs**: Rainfall, sediment, and energy from gravity.
* **Processes**: Erosion (e.g., headward erosion), transportation (e.g., bedload, suspended load), and deposition.
* **Outputs**: Sediments to the sea, energy dissipation.
* **Feedback**: Channel incision can increase sediment supply, while vegetation can reduce runoff and erosion.

### **Importance of the System Concept in Geomorphology**

* **Holistic Understanding**: Helps in understanding the interconnections between landforms and processes.
* **Predictive Capability**: Useful for anticipating changes due to natural or human-induced factors.
* **Environmental Management**: Aids in solving practical problems like erosion control, flood management, and land-use planning.

This systems approach underscores the dynamic and interconnected nature of Earth's surface processes, making it an essential tool in geomorphic studies.

***20. Steady State Concept in Geomorphology***

Q. What is steady state in geomorphology

In geomorphology, **steady state** refers to a condition where the form and processes of a landscape remain relatively constant over time, despite ongoing dynamic processes such as erosion, deposition, and weathering. This concept is rooted in the balance between forces shaping the landscape and the system's ability to adjust to changes.

### Characteristics of Steady State

### **Dynamic Equilibrium---** Landforms achieve a balance between inputs (e.g., sediment supply, energy) and outputs (e.g., sediment removal). While individual components (e.g., rocks, sediment) may change, the overall system appears stable.

* 1. **Time-Scale Dependent--** Steady state is observed over specific time scales; on longer time scales, tectonic or climatic changes might disrupt the equilibrium.
  2. **Feedback Mechanisms--** Negative feedback helps maintain steady state by counteracting disturbances (e.g., increased erosion rates due to uplift balanced by deposition downstream).

### Types of Steady States

1. **Static Steady State**
   * No noticeable changes occur over short time periods (e.g., days or months).
2. **Dynamic Steady State**
   * Fluctuations occur, but averages over a longer period remain constant (e.g., river discharge in a watershed over decades).
3. **Metastable Steady State**
   * The system remains stable until a threshold is crossed, leading to a sudden adjustment (e.g., landslides after a critical slope angle is exceeded).

### Examples in Geomorphology

1. **River Systems**
   * A river adjusts its slope and channel shape to maintain a balance between sediment load and water flow.
   * Example: A graded stream achieves a steady state where erosion and deposition rates are balanced.
2. **Hillslopes**
   * Hillslopes adjust their angle to balance the forces of gravity and material strength, maintaining a steady slope profile over time.
3. **Coastal Systems**
   * Beaches achieve steady state when sediment input (e.g., from rivers) equals sediment output (e.g., via wave erosion).

### Importance of Steady State in Geomorphology

1. **Understanding Landscapes**
   * Provides insights into how landscapes evolve and maintain equilibrium over time.
2. **Environmental Management**
   * Helps predict how landscapes respond to natural or human-induced changes, aiding in planning and conservation.
3. **Theoretical Basis**
   * Forms the foundation for models like **dynamic equilibrium theory**, which explains landscape evolution.

### Limitations of the Steady State Concept

1. **Assumption of Constancy**
   * Real-world landscapes are rarely in perfect equilibrium due to constant changes in tectonics, climate, and human activities.
2. **Threshold Effects**
   * Systems can remain in steady state only until critical thresholds are reached, leading to abrupt changes.

While idealized, the steady state concept is a powerful tool for understanding and analyzing the balance and dynamics of geomorphic systems.

***21. Who put forward the concept of steady state in geomorphology?***

The concept of **steady state** in geomorphology was primarily advanced by **G.K. Gilbert** in the late 19th century. Gilbert, an American geologist, is widely regarded as one of the pioneers of modern geomorphology. His work emphasized the balance between erosional and depositional processes in shaping landforms.

### **Key Contributions by G.K. Gilbert:**

1. **Dynamic Equilibrium Concept**
   * Gilbert proposed that landscapes adjust their forms to achieve a balance (equilibrium) between forces such as erosion, deposition, and tectonic uplift.
   * This adjustment results in a condition where changes occur, but the overall form of the landscape remains constant over time.
2. **Graded Streams**
   * Gilbert introduced the idea of a "graded stream," where a river adjusts its slope and flow to balance sediment transport and energy expenditure, reflecting a steady-state condition.

### **Later Developments**

The concept of steady state was further refined in the 20th century by geomorphologists like:

* **Walter Penck**: Focused on the balance between uplift and denudation.
* **John Hack**: Introduced the idea of **dynamic equilibrium** in 1960, emphasizing that landforms evolve to maintain a steady state between forces acting on them and the processes they drive.

These ideas have become central to understanding landscape evolution and the interplay of geomorphic processes.

***22. Dynamic equilibrium concept in geomorphology***

The **dynamic equilibrium concept** in geomorphology explains how landscapes adjust to achieve a balance between opposing forces, such as tectonic uplift and erosion, over time. Although continuous changes occur in the system, the overall form of the landscape appears stable because of these adjustments.

This concept emphasizes that landscapes are dynamic systems that evolve to maintain equilibrium under varying environmental and geological conditions.

### **Key Features of Dynamic Equilibrium**

1. **Balance Between Forces**
   * Dynamic equilibrium is the balance between:
     + **Driving Forces**: Tectonic uplift, gravity, and climatic factors.
     + **Resisting Forces**: Erosion, weathering, and deposition.
2. **Time-Scale Dependence**
   * Short-term variations occur due to events like storms or floods, but over longer periods, the system maintains a stable average condition.
3. **Feedback Mechanisms**
   * Negative feedback stabilizes the system by counteracting disturbances.
     + Example: Increased erosion on a steep slope may reduce its steepness, stabilizing the landscape.
4. **Thresholds**
   * The system can remain in equilibrium until a threshold is crossed, causing rapid adjustments (e.g., landslides, river avulsions).

### **Development of the Concept**

The dynamic equilibrium concept was formalized by **John T. Hack** in 1960. Hack proposed that landforms evolve to maintain a balance between the processes acting on them and the forces driving these processes. His idea built on earlier work by **G.K. Gilbert**, who introduced the idea of equilibrium in geomorphology.

### **Examples in Geomorphology**

1. **River Systems**
   * Rivers adjust their gradient, width, and depth to balance sediment load and water flow, achieving a state of dynamic equilibrium.
     + Example: A graded stream maintains a profile where erosion and deposition rates are balanced.
2. **Hillslopes**
   * Hillslopes evolve to balance the rate of material removal (e.g., erosion) with the rate of material supply (e.g., weathering).
3. **Coastal Systems**
   * Beaches achieve equilibrium when the rate of sediment supply equals sediment removal by wave action.
4. **Tectonic Settings**
   * In tectonically active areas, uplift is balanced by denudation processes (e.g., erosion), leading to the steady development of mountainous landscapes.

### **Importance of the Dynamic Equilibrium Concept**

1. **Understanding Landscape Evolution**
   * Provides insights into how landscapes respond to natural and anthropogenic changes.
2. **Predictive Capability**
   * Helps geomorphologists predict long-term changes in landforms due to factors like climate change or tectonic activity.
3. **Environmental Applications**
   * Useful in managing river systems, soil erosion, and coastal protection projects.

### **Limitations of the Concept**

1. **Simplification of Complex Processes**
   * Landscapes are influenced by numerous factors, and achieving perfect equilibrium is rare.
2. **Threshold Effects**
   * Once a threshold is crossed, the system may rapidly shift to a new state, making equilibrium difficult to predict.
3. **External Influences**
   * Changes in climate, vegetation, or human activities can disrupt the balance and lead to new dynamics.

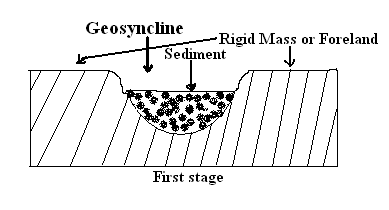
The **dynamic equilibrium concept** remains a cornerstone in geomorphology, providing a framework to study and understand the balance and evolution of Earth's landforms over time.

**========================================================================**

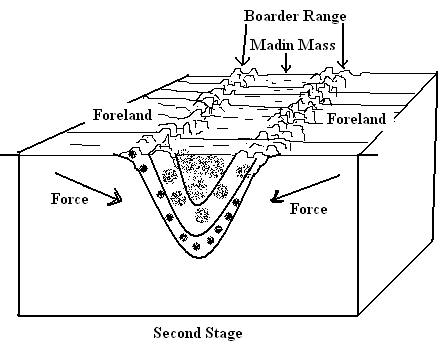
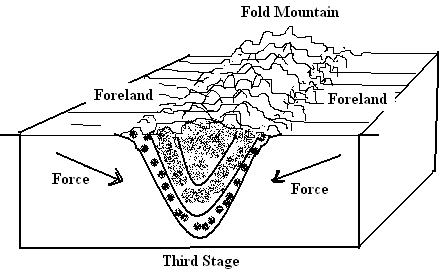
***23. Mountain Building Theory of Kober (Geosyncline Theory)***

*Question-Discuss the theory of Kober and examine its relevance to the Himalayan orogeny.*

*Question-Discuss the mountain building theory of Kober. How does this theory explain the formation of the Himalaya? Question-Discuss the mountain building forces as explained by Kober.*

**Answer-** Kober was a German geologist. He attempted to explain the origin of mountain on the basis of **his geosynclinals theory**. He also attempted to elaborate the formation of mountains, their geological history and their evaluation and development. The theory is the result of his study of the western Alps. According to him folded mountain are the result of the upliftment of sediment that deposited in geosynclines located between two forelands. According to Kober, to form a mountain there are three main stages.

**The first stage or Lithogenesis:-** Lithogenesis is the first stage of mountain building. In this stage geosynclines were formed. The geosynclines are long and wide mobile zone of water which is bordered by rigid masses. The rigid masses have been known by Kober as Foreland. The rigid masses are subjected to continuous erosion by fluvial processes and eroded materials are deposited in the geosyncline. As a result of sedimentation in the geosyncline as well as increasing load, the beds of geosyncline are subjected to gradual subsidence and the sediment become thicker.

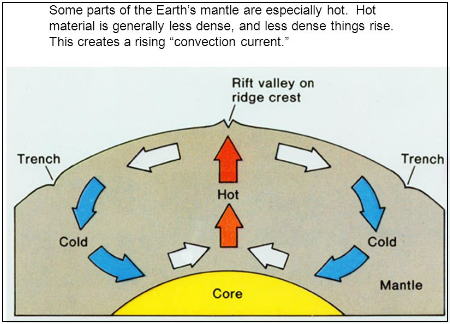
**The second stage or Orogenesis:-** In the second stage both the Forelands start to move towards each other. As a result, the sediments of the geosyncline are squeezing and ultimately folding processes start to form mountain ranges. The parallel ranges formed on either side of the geosyncline have been formed by Kober as Randketten. According to Kober, folding of sediments depend upon the intensity of compressive forces. If the compressive forces are normal, the marginal sediments of the geosyncline are folded but the middle portion of the geosyncline remains unfolded which is called Median Mass. If the compressive forces are acute, the whole sediments are compressed, squeezed and ultimately folded.

**The third stage – Gliptogenesis:-** The third stage of mountain building is characterized by gradual rise of mountains and their denudation by fluvial or other processes. As a result gradual lowering of the height of mountains started.

**The forces of mountain building:-** Kober believed that the force related to mountain building is thermal compression. Now the other geologist does not agree with thermal contraction only. They believed that very mountain like the Alps, the Himalayas, the Rockies and the Andes cannot be formed by the force of contraction generated by cooling of the earth.

**The formation of Himalayan:-** Kober distinguishes six main mountain building periods. The last great period of orogenic activity is the Alpine, which extended through particularly all the Mesozoic and the greater part of the Tertiary periods. According to him Alps-Himalayan ranges are the result of the squeeze out of the sediment of the Tethys geosyncline. He believed that the Tethys geosyncline was extended from Gibraltar to Sunda Island, between the forelands of Europe-Russian and Africa-Indian. In his theory he mentions that the Russian platform was stable and Indian plate is moving. The Himalaya range is located between the Angaraland and the Deccan plateau.

***24. Mountain Building Theory of Holmes (Thermal Convection Current Theory)***

The Thermal Convection Current hypothesis dates back to Hopkins (1839) and Fisher (1881), but credit goes to Arthur Holmes for presenting more elaborately the same as a force for mountain building, continental drift, volcanism and formation of ocean trenches etc. Holmes first discussed and illustrated his view in 1928 in his monumental work - Principles of Physical Geology. This theory of mountain building is now mostly accepted as the most convincing. It is similar to the latest theory, i.e. plate tectonics. Holmes was a 'Convectionist' who based his theory on thermal convection currents in the substratum of the earth.

Radioactive heating is the main source of heat flow in the continents. Consequently this heat is higher in those regions where crust is thicker, e.g., in orogenic belts. However, the amount of radioactive heat transmitted from the mantle to the crust is insignificant. But volcanic activity or igneous intrusion meaning transfer of hot matter from the interior greatly increases heat flow. The basaltic crust below the oceans is less radioactive than the sialic continental crust. The oceanic crust is thinner than the continental crust. Thus, high heat flow over mid-oceanic ridges such as, Mid-Atlantic Ridge is indicative of thermal convection currents.

According to Holmes, Mid-oceanic rise, new oceans, continental borderland, ocean deeps and pattern of heat flow, all are related to thermal convection currents.

Thus, heats producing radioactive minerals are concentrated in the sialic crust and very little of radioactive heat flow comes from the mantle. Therefore, sub-crustal convection currents are supposed to be the probable and primary force for the tangential movement in the crust which causes mountain building or ocean deep formation or the development of mid-oceanic ridges.

Holmes is of the opinion that "whatever may be the source of activating energy, the general consistency of the above estimates (but not quite) raises the convection hypothesis to the dignity of a theory".

**Holmes' views summarised:**

(i) Mountain building and other geophysical phenomena are the result of thermal convection currents of molten magma which occur in the upper parts of the mantle periodically.

These have great transporting power causing convergence and compression of the solid crust or bending it down when the currents descend or tearing it apart where the currents diverge.

(ii) The contribution of radioactive heat is too little to cause the melting of the subcrustal layers. It is, therefore, inferred that additional heat, which is necessary to cause melting of rocks in the substratum, comes from the mantle not by conduction of radioactive heat but by thermal convection currents of molten magma.

(iii)The hypothesis of thermal convection currents has been almost but not quite raised to the status of a theory,. There are indirect evidences such as abnormally high heat flow on mid-oceanic ridges suggesting the existence of convergent sub-crustal currents.

**Three stages of the thermal convection currents:**

(i) The first phase is that of long period with currents gradually gaining speed. In areas of convergence geosynclines are formed and mountain root begins to develop.

(ii) The second phase is of short duration with rapid currents. Roots of mountains grow. The orogenic belt is thrust, faulted, folded and various features of mountains including nappes, gravity sliding, etc. are developed.

In areas of divergent currents this third phase produces mid-oceanic ridges, volcanic activity, high heat flow, and ocean-floor spreading.

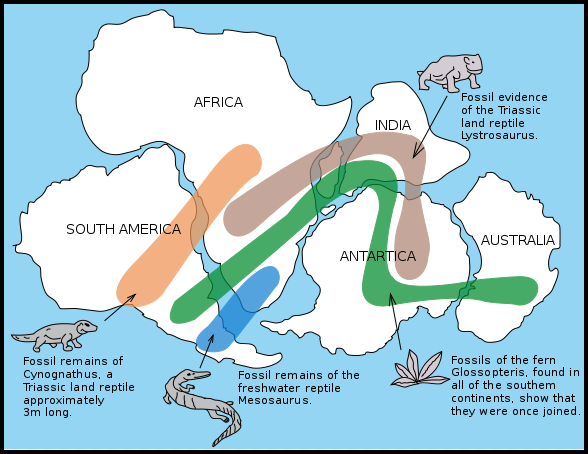
(iii).In the last phase which is marked by declining currents, the down-dragging power of currents has waned and the mountain root of geosynclinal sediments, which are obviously relatively light and could not be held down into heavier matter of the interior, is released and rises. Thus, the final uplift of the orogenic belt occurs.

***25. Continental Drift Theory---Origin and Development of Major Landforms – Views of Alfred Wegner, Lothian Green.***

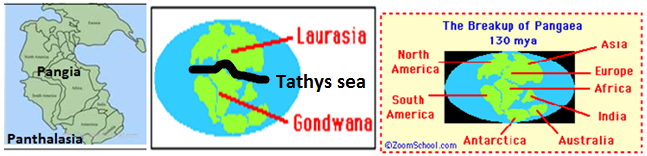
Question- Explain critically the views of Alfred Wegener continental drift theory on the origin and development of continents.

**Answer-** Oceans and continents are the major landforms of the earth crust. The question is how they are originated. To answer this question, different geologist and geophysics put forwarded their theories. The theory of continental drift forwarded by Wegener is an attempt to explain the present arrangement of continents and ocean basin.

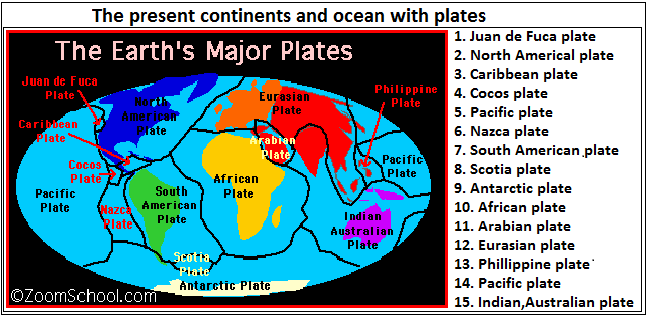
Originally Alfred Wegener was a climatologist. He found that the cold climatic area like Greenland, Tundra, etc. was suffering from hot and humid climate. Similarly, the present hot and humid climatic area like Brazil, Peninsula, India, Australia, South Africa, etc. was covered by glaciers. To answer such type of climate change, Wegener assumed that the land mass might have been displaced and drifted.

Wegener put forwarded the Continental Drift Theory in 1912. He assumed that there was a super continent called Pangaea, surrounded by an ocean called Panthalasia. Wegener hypothesized that the Pangaea broke up in to two parts. The northern part was called Laurasia or Angaraland and the Southern part was called Gondwanaland. These two blocks were separated by a long shallow inland sea called the Tathys. In Carboniferous period (about 300 million years ago) the Laurasia and Gondwanaland started breaking. The present continent like Noth America, Greenland, Europe, North of Indian subcontinent came from Laurasia and South America, Madagascar, India, Arabia, Malaysia, East Indies, Australia and Antarctica are the result of breaking Gondwanaland. ****

In the opinion of Wegener, the continents drifted in two directions- (i) towards the equations and (ii) towards the west. As a result of equator word drift, Africa and Europe close together and the sediment of Tethys Sea raised up as folded mountain. According to him the Alps, Altai, Tienshan, Himalaya, etc. were developed from Tethys Sea.

The west wards movement was due to the tidal force of the Moon and the Sun. Due to west ward drift, North America and South America got separated from Europe and Africa and Atlantic Ocean came into existence. Wegener assumed that equator ward drift took place during Mesozoic era and west ward drift took place during Tertiary period. The Rockies and the Andes were formed as a result of the west ward drift of Americas. Wegener cited various evidences to show that the continents were close together. These were-

**1.** **Jig saw fit of continents**:- The outline of the coasts of Atlantic Ocean can easily be joined together. The eastern castes of America can be fitted against the western coast of Gulf 0f Africa and Brazilian peninsula into the Gulf of Guinea.

**2. Structural evidence:-** A number geological features are found at the continents facing the Atlantic ocean. The folded mountain ranges at the southern tip of Africa, Appalachian in North America and those in Ireland and Brittany are only a few examples that prove that these continents were joined together in the past.

**3. Fossil evidence:-** Similar fossils are found on the continents on both side of the Atlantic ocean.

**4. Palaeo climatic evidence:** - Great coral deposits in Antarctica show that abundant plant life flourished on that continent new covered with thick ice.

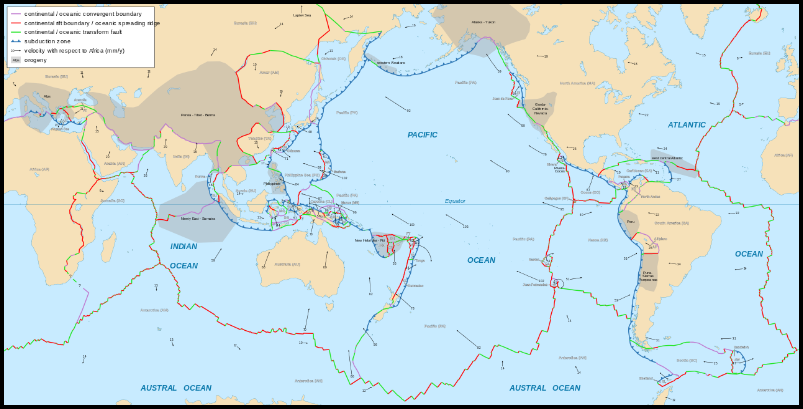
Besides these, a number of evidences put forwarded by Wegener which indicates that the continents are drifting from one landmass to the present situation.

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***26. Plate Tectonics Theory.***

The term plate tectonic was first used by Tuzo Wilson of the University of Toronto in 1965. But the theory of plate tectonic was first published by W.J. Morgan. This theory is based on the concept of sea-floor spreading advocated by Harry H.Hess. It is the improvement over the Wagener’s theory of continental drift.

The term ‘tectonics’ comes from the Greek word ‘tektonikos’ refers to the deformation of the earth’s crust. The theory believes that the shape and size of the plate of the earth crust is changing due to considerable geologic activity, such as sea-floor spreading, volcanic eruptions, mountain building, continental drift, etc.

 In the theory it is proposed that the entire surface of the earth comprises of internally rigid but relatively thin (100-150 km thick) plate. According to La Pichan (1968) there are seven major and nine minor plates. Most of the plates include both continental and oceanic crusts. The area of the plates is fairly large in comparison to their depth. They move independently at different rates. Generally three types of motion are possible between the plates. They are (i) divergent (ii) convergent and (iii) friction on shearing. The boundary of these plates is zones of tectonic activity, where earthquakes and volcanic eruptions tend to occur.

**Origin of Continents and Ocean Basin In the light of Plate Tectonic Theory:-**

It is already mentioned that the theory of plate tectonic is the improvement over the Wegener’s theory of continental drift who for the first time (1915) put forwarded the idea of the origin of continents and ocean basin.

The ocean and continents are the main features of the earth. The question is how did they originate? To answer to this question different geologist and geographers put forward their different theories. The plate tectonic theory is the recent develop theory through which able to explain the origin and development of the continent and ocean basin.

In Plate Tectonic Theory, it is believed that currently there are seven large and several small plates. The largest plates include the pacific, North American, Eurasian, Antarctic and African plate. The small plates include Cocos, Nazca, Caribbean, Gorda, etc. In has been now validated that all these plates along with ocean basin never been stationary and permanent at their places. They have always been mobile and are still moving in relation to each other. It is believed that 300 million years age, there was only one landmass on the surface of the earth known as Pangaea and it was covered by water body known as panthalasia.

About 180 million years ago the Pangaea began to start breaking. It breaks in to two major parts. The northern parts known as Laurasia and the Southern part is known as Gondwanaland and the water bodily between the two lands mass is known as Tathys. About 160 million years both the land mass began to break into different plates and started to move in different direction. As a result during 100 million years ago the India and Australia appeared as independent plate. After that North and South America started to move towards west and as a result Atlantic Ocean formed. The Greenland broke away from Labrador and thus Labrador Sea was formed. About 60 million ago Rockall plateau was separated from Greenland. Indian plate began to move towards Asiatic plates through Tethys Sea and Australian-Antarctic plates began to move southward. As a result the Pacific Ocean began to shrink in size and Atlantic and Indian Ocean began to expand. It may be pointed out that the Atlantic Ocean is continuously expanding for the post 200 million years but the Pacific Ocean is contracting in size because of the westward movement of the Americas.

The following examples demonstrate the trends and patterns of continental displacement. The shape and size of continents and ocean basins is ever changing. It is mainly due to plate movement responsible for convection current of the earth interior.

***27. Concept of Isostacy***

**Impact of Isostacy on landform development**

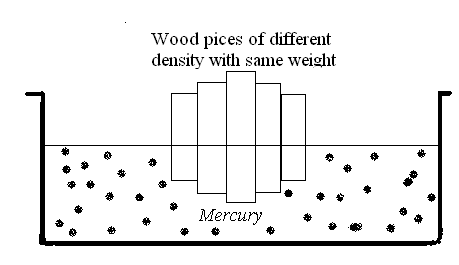
2007- Define the term ‘Isostacy’. Discuss how the theory of isostacy helps in interpreting the major relief feature of the earths. 2+13=15

1993- Examine the concept of isostacy and state the role it plays in mountain building. 5+10=15

1996- What is mean by isostacy? What is level of compensation? Explain the theory of Hayford Bowie in this regard? 5+5+5=15

**Answer**- The term isostacy was used by the American geologist Dutton in 1859. It refers the state of gravitational equilibrium that exists between continents and ocean floor and the mountains, plateaus and plains. This means that the outer crust of the earth is floating on a denser substratum beneath. Dutton believed that the height of different features is related to their density. In other words, the higher features were composed of lower density and the lesser height feature was composed of higher density.

Besides, Pierre Bouger (1735), Sir Geogre Everest (1859), Archdeacon Pratte (1855), Sir George Airy (1855), Hayford and Bowie, Joly, Holmes, etc. put forwarded their ideas about how and why the different relief features of the earth do exist.

Pierre Bougure mentioned that the gravitational attraction of the Andes is much smaller than that to be expected. Similar discrepancies were noted during the geodetic survey of the Indo-Gangetic plain for the determination of latitudes. Under the supervision of Sir George Everest, Archdeacon Pratt attempted to estimate the amount of attraction of the Himalayas on the basis of assumption. He assumed that the entire mountain had the average density 2.75. He found that the Himalaya was not exerting the attraction according to its enormous mass. The discrepancies of the gravitational deflection of the plumb-line and numerous explanations for these discrepancies resulted into the postulation of the concept of isostacy by different scientists. The view of a few of them is presented below.

**The View of Sir George Airy-**

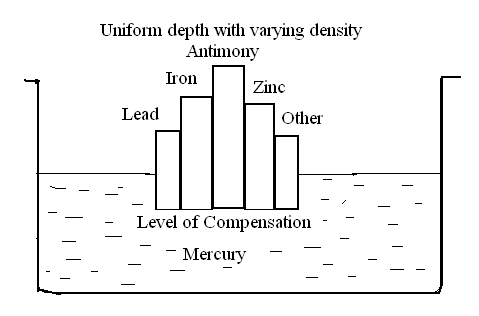
According to Airy the curst of the earth is composed of relatively lighter materials which are floating in the substratum of denser material. According to him the Himalayas are floating in denser glassy magma. There is a level surface of denser material beneath the Himalayas and the root of the Himalaya sink into the denser material beneath like iceberg floating in water. He mentioned that the crystal parts (landmass) were floating like a boat in the magma of the substratum. Airy postulated that if the land column above the substratum is large, its greater part would be submerged in the substratum and if the land column is lower its smaller part would be submerged in the substratum. According to Airy the density of different columns of the land remains the same. This means that the continents are made of rocks having uniform density but their volume or length varies from place to place. Airy took several pieces of iron of varying lengths and put them in a basin full of mercury. These pieces of iron sunk up to varying depths depending on their lengths (as shown in the Fig. below)-

**Views of A. Pratt-**

The views of Pratt is different from the Airy. According to Pratt the density of the material of different feature is different. He put forwarded that the density of mountains is less than the density of plain and the density of plain is less than the density of oceanic floor and so on. This means that there is inverse relationship between the height and density.

According to Pratt there is a level of compensation above which there is variation in the density of different columns of land but there is no change in density below this level. The central theme of the concept of Pratt on isostacy may be expressed as ‘uniform depth with varying density’. This statement may be explained with an example given below.

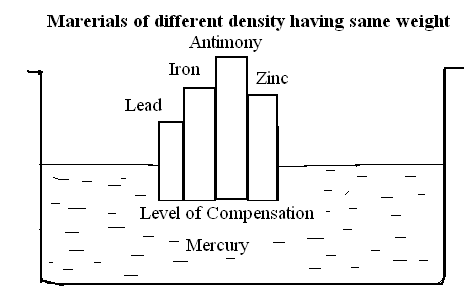
According to Pratt different relief features are standing only because of their equal mass along the line of compensation.



**Views of Hayford and Bowie**

The concept of Hayford and Bowie is almost similar to the concept of Pratt. According to them there is a plane where there is complete compensation of the crustal parts. Above this level, the density varies with elevations and below this level the density is almost similar. He examined that the density of mountains is lesser than the ocean floor. According to Hayford and Bowie, there is an inverse relationship between the height of columns of the earth’s crust and their respective densities above the line of compensation. They supposed that the level of compensation is located at the depth of about 100km. The views of Hayford and Bowie can be understood with the help of the following diagram.

**Views of Joly**

 Joly criticized the views of Hayford and Bowie. His main objection was about the depth of compensation (100km). He believed that at a depth of 100 km, the temperature will so high that all rocks would melt and become liquid. According to Joly there is a layer of 16 km thick below the crust which is known **as level of compensation.** The compensation level is not as a straight line surface. In his opinion the crust of the earth consists of lighter materials and the density is 2.06. Below the crust Sima is situated whose average density is 3. The Sial is penetrating into the Sima.

Like Joly Holmes also examined that the higher relief features of the earth’s surface are composed of lighter materials and their portion penetrated into the heavier and denser rocks below.

From the above discussion it is clear that the crust of the earth is consist of lighter materials than the Sima. Between the Sial and Sima layer there is 10-16km thick layer which is known as level of compensation. In this layer a part of the crust is penetrated. In this layer the column of each feature of the earth’s crust is giving equal pressure which is known as isostatic adjustment. If the load of a column increase than it sink into the substratum. Similarly a column rise when its load decreases. In this way the major relief feature of the earth crust like mountain, plateau, plain, sea floor, etc, do exist.

# *28. What is Earth’s Movement:-*

# Earth movement refers to the deformation of earth’s crust due to certain forces acting from interior of the earth. These deformations are caused by the movements generated by various factors which are not completely understood. The factors are given below.

1. The heat generated by the radioactive elements in earth’s interior.

2. Movement of the crustal plates due to tectogenesis.

3. Forces generated by rotation of the earth.

4. Climatic factors

5. Isostacy—according to this concepts, blocks of the earth’s crust, because of variations in density would rise to different levels and appear on the surface as mountains, plateaux, plains or ocean basins.

***29. What is Landforms***

Landforms of the Earth refer to the natural physical features that make up the Earth's surface. These features are shaped by various geological processes such as erosion, weathering, deposition, tectonic activity, and volcanic activity over time. Landforms exist in diverse shapes, sizes, and types, and they are categorized based on their origin and appearance.

### **Examples of Landforms**

1. **Mountains**: Elevated areas with steep sides, often formed by tectonic activity (e.g., the Himalayas).
2. **Valleys**: Low areas between mountains or hills, often carved by rivers (e.g., the Great Rift Valley).
3. **Plains**: Flat or gently rolling areas, often formed by sediment deposition (e.g., the Great Plains of North America).
4. **Plateaus**: Elevated flatlands, often formed by volcanic activity or uplift (e.g., the Deccan Plateau in India).
5. **Hills**: Elevated areas smaller and less steep than mountains.
6. **Deserts**: Arid regions with little vegetation, shaped by wind erosion and deposition (e.g., the Sahara Desert).
7. **Deltas**: Landforms at river mouths where sediment is deposited (e.g., the Nile Delta).
8. **Lakes**: Water bodies surrounded by land, formed by glacial, volcanic, or tectonic activity.
9. **Canyons**: Deep valleys with steep sides, often carved by rivers (e.g., the Grand Canyon).
10. **Volcanoes**: Mountains formed by the eruption of magma (e.g., Mount Fuji in Japan).

These landforms not only define the Earth's physical geography but also influence human settlement, climate, biodiversity, and economic activities

***30. What is Geomorphic Process***

Geomorphic processes are natural mechanisms that shape and modify the Earth's surface, resulting in the formation of various landforms. These processes are driven by energy from the Earth's interior, gravity, and external forces like wind, water, and ice. Geomorphic processes are categorized into two main types:

### **1. Endogenic Processes (Internal)--** These processes originate within the Earth's interior and are driven by tectonic and volcanic activities. They typically involve the construction of landforms.

* **Tectonic Processes**: Movements of the Earth's lithosphere, such as plate tectonics, folding, faulting, and uplift.
* **Volcanic Activity**: Formation of landforms like volcanoes, lava plateaus, and volcanic islands.

### **2. Exogenic Processes (External)--** These processes are driven by external forces, primarily the atmosphere, hydrosphere, and biosphere. They usually involve the wearing down, transportation, and deposition of Earth's materials.

* **Weathering**: Breakdown of rocks in situ by physical, chemical, or biological means.
* **Erosion**: Removal of surface materials by agents like water, wind, ice, and gravity.
* **Transportation**: Movement of eroded materials to new locations by rivers, glaciers, wind, or ocean currents.
* **Deposition**: Accumulation of transported materials in new areas, leading to landform development such as deltas and sand dunes.

### **Examples of Landforms Created by Geomorphic Processes**

* **Mountains**: Formed by tectonic uplift.
* **Rivers and Valleys**: Shaped by fluvial processes.
* **Deserts**: Formed by wind erosion and deposition.
* **Glacial Features**: Created by ice erosion and deposition.
* **Coastal Features**: Developed through wave action and sediment movement.

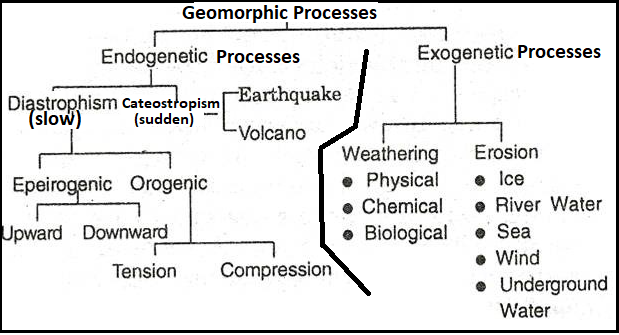
These processes interact over time to continuously shape the Earth's surface, creating diverse landscapes.

***31. Endogenetic Processes***

Endogenetic processes are internal forces and phenomena originating from within the Earth's crust that shape the Earth's surface. These processes are driven by energy from within the Earth, primarily due to heat and pressure generated by radioactive decay and residual heat from the Earth's formation.

### **Types of Endogenetic Processes**

**Tectonic Processes**/ **Diastrophism/ slow movement:-** Caused by the movement of tectonic plates due to convection currents in the mantle. Diastrophic processes are two types. They are orogenic and epeiorgenic.



**A. Orogeny**: Mountain-building processes (e.g., formation of the Himalayas). **Folding**: The bending of rock layers due to compressional forces (e.g., the Appalachian Mountains). **Faulting**: The fracturing of the Earth's crust due to tensional, compressional, or shearing forces (e.g., San Andreas Fault). Orogenic or the mountain-forming movements act tangentially to the earth surface, as in plate tectonics. Tensions produces fissures (since this type of force acts away from a point in two directions) and compression produces folds (because this type of force acts towards a point from two or more directions). In the landforms so produced, the structurally identifiable units are difficult to recognise. In general, diastrophic forces which have uplifted lands have predominated over forces which have lowered them. (For diagrams showing effects of Diastrophic Movement

**B. Epeirogeny**: Uplift or subsidence of large landmasses without significant folding. Epeirogenic or continent forming movements act along the radius of the earth; therefore, they are also called radial movements. Their direction may be towards (subsidence) or away (uplift) from the centre. The results of such movements may be clearly defined in the relief.

1. **Volcanism**:
   * The eruption of magma from beneath the Earth's crust to form features like volcanoes, lava plateaus, and volcanic islands.
   * Examples: Formation of the Hawaiian Islands.
2. **Earthquakes**:
   * Sudden movements or vibrations in the Earth's crust caused by tectonic activity or volcanic eruptions. Examples: The 2004 Indian Ocean earthquake.

**Characteristics of Endogenetic Processes**

* Operate beneath or within the Earth's crust.
* Can result in the creation of new landforms such as mountains, plateaus, and rift valleys.
* Usually slow and long-term but can sometimes lead to sudden, catastrophic events like earthquakes and volcanic eruptions.

These processes are a major factor in shaping the Earth's surface over geological timescales and contribute to the dynamic nature of the planet.

***32. Exogenetic Processes***

Q. Discuss the exogenetic processes in landform development

Exogenetic processes, also known as **exogenic processes**, are external forces that shape the Earth's surface. These processes are primarily driven by energy sources external to the Earth, such as the Sun's radiation, gravity, and atmospheric forces. They play a critical role in landform development by breaking down, transporting, and depositing materials on the Earth's surface. The four main types of exogenetic processes are **weathering**, **erosion**, **mass wasting**, and **deposition**.

### **1. Weathering**: The Breakdown of Rocks

Weathering is the process of disintegration and decomposition of rocks at or near the Earth's surface. It can be categorized into three types:

* **Physical (Mechanical) Weathering**:
  + Caused by temperature changes (freeze-thaw cycles, thermal expansion), pressure release, or abrasion.
  + Example: Exfoliation domes due to unloading, frost shattering in cold climates.
* **Chemical Weathering**:
  + Involves chemical reactions like hydrolysis, oxidation, and carbonation.
  + Dominant in warm and wet climates.
  + Example: Formation of karst landscapes through the dissolution of limestone by carbonic acid.
* **Biological Weathering**:
  + Caused by plants, animals, and microorganisms (e.g., root wedging, organic acids breaking down rock minerals).
  + Example: Tree roots cracking rocks in forested areas.

### **2. Erosion**: Removal and Transport of Material

Erosion involves the detachment and movement of surface material by agents like water, wind, ice, and gravity. It is more dynamic than weathering as it reshapes landscapes.

* **Water Erosion**:
  + Includes processes like sheet erosion, rill erosion, gully erosion, and river erosion.
  + Example: Formation of river valleys and canyons (e.g., Grand Canyon).
* **Wind Erosion**:
  + Common in arid and semi-arid regions.
  + Processes include deflation (removal of fine particles) and abrasion (sandblasting of surfaces).
  + Example: Sand dunes in deserts.
* **Ice Erosion (Glacial)**:
  + Glaciers erode through plucking and abrasion, forming U-shaped valleys and fjords.
  + Example: Glacial troughs in the Alps.
* **Coastal Erosion**:
  + Wave action erodes coastal features, forming cliffs, arches, and stacks.
  + Example: The Twelve Apostles in Australia.

### **3. Mass Wasting**: Gravity-Driven Movement

Mass wasting is the downslope movement of soil, rock, and debris under the influence of gravity. It occurs when the gravitational force exceeds the resisting forces of the slope.

* **Types of Mass Wasting**:
  + **Creep**: Slow movement of soil downslope.
  + **Slides**: Sudden movement along a plane of weakness (e.g., landslides).
  + **Flows**: Movement of material as a viscous fluid (e.g., mudflows, debris flows).
  + **Falls**: Freefall of rock or debris (e.g., rockfalls).
* **Example**: Landslides triggered by heavy rainfall or earthquakes.

### **4. Deposition**: Accumulation of Material

Deposition occurs when transported materials are laid down in new locations due to a decrease in the energy of the transporting agent.

* **Depositional Features**:
  + **Fluvial Deposition**: Forms deltas, floodplains, and alluvial fans.
  + **Aeolian Deposition**: Forms loess deposits and sand dunes.
  + **Glacial Deposition**: Creates moraines and drumlins.
  + **Coastal Deposition**: Forms beaches, spits, and barrier islands.
* **Example**: Formation of the Nile Delta through river sediment deposition.

### **Significance of Exogenetic Processes in Landform Development**

1. **Dynamic Landscapes**:
   * Exogenetic processes constantly reshape landscapes, maintaining a balance with endogenetic (internal) forces like tectonics.
2. **Formation of Diverse Landforms**:
   * Valleys, mountains, plateaus, plains, and coastal features are shaped by a combination of weathering, erosion, mass wasting, and deposition.
3. **Influence of Climate and Environment**:
   * The intensity and type of exogenetic processes vary with climatic conditions (e.g., glacial erosion in cold climates, wind erosion in arid regions).
4. **Human and Ecological Impacts**:
   * These processes affect soil fertility, water resources, and hazard risks (e.g., floods, landslides).

***33. Idea of Penck on geomorphic processes***

Albrecht Penck, a prominent German geographer and geomorphologist, made significant contributions to understanding geomorphic processes, particularly through his work on landscape evolution and climatic influences. His ideas emphasized the interplay between tectonics, climate, and erosion in shaping the Earth's surface.

### **Key Ideas of Penck on Geomorphic Processes:**

1. **Role of Tectonics**:-- Penck highlighted the importance of tectonic uplift in shaping landforms. He suggested that the rate of uplift relative to the rate of erosion plays a critical role in determining the characteristics of landscapes.
2. **Dynamic Equilibrium**:--- Penck proposed that landscapes are in a state of dynamic equilibrium, where the uplift of land and its erosion by external forces (e.g., rivers, glaciers, and wind) are balanced over geological time scales.
3. **Erosion and Climatic Influence**:--- Penck recognized that climate heavily influences the rate and type of erosion, as processes like frost action, river incision, and glacial carving vary under different climatic conditions.
4. **Valley Development**:-- Penck's studies contributed to understanding valley formation and how rivers adjust to changes in base level, tectonic activity, and climate.
5. **Youth, Maturity, and Old Age of Landforms**:-- Penck refined ideas similar to those of William Morris Davis but placed more emphasis on the continuous interplay of uplift and erosion rather than Davis's cycle of erosion theory, which implies a more rigid sequence of stages.
6. **Recognition of Glacial Cycles**:-- Penck's work with his son, Walther Penck, focused on glacial geomorphology and the recognition of glacial-interglacial cycles, significantly contributing to our understanding of past climatic changes and their geomorphic impacts.

Penck's ideas provided a foundation for modern geomorphology, emphasizing a more process-oriented and less deterministic view of landscape evolution than earlier theories. His work also influenced the study of climate's role in geomorphic systems and the importance of integrating multiple factors—like tectonics and erosion—in landscape analysis.

***34. Idea of L.C. King on geomorphic processes***

L.C. King (Louis C. King), a South African geomorphologist, developed a theory of landscape evolution that contrasted significantly with the ideas of William Morris Davis and Albrecht Penck. King's work was particularly rooted in the context of arid and semi-arid landscapes, where he observed features that were not well explained by existing models.

### Key Ideas of L.C. King on Geomorphic Processes:

1. **The Concept of Peneplanation**:--- King proposed peneplanation as a dominant process of landscape evolution. Unlike Davis’s cyclical theory, King emphasized the role of long-term processes that lower a landscape to near-sea-level over extensive timescales, creating gently sloping surfaces called peneplains. Peneplains develop through lateral planation by streams, which erode valley sides rather than deeply incising the landscape.
2. **Scarp Retreat Model**:--- One of King’s most significant contributions was the scarp retreat or parallel slope retreat model. He argued that in semi-arid regions, steep escarpments (scarps) retreat laterally rather than eroding vertically. This process maintains the shape of the scarp over time, resulting in wide, gently sloping pediments (flat areas at the base of escarpments) rather than valleys.
3. **Pediplanation**:  
   King introduced the concept of pediplanation, which involves the formation of pediments (rocky, gently sloping surfaces) through the combination of scarp retreat and weathering processes. This differs from peneplanation in that it focuses on arid and semi-arid environments and emphasizes the role of sheet erosion and surface runoff.
4. **Dynamic Equilibrium in Landscape**:-- Similar to Penck, King emphasized dynamic equilibrium in landscapes. He proposed that landscapes evolve continuously under the influence of tectonic stability and climatic conditions, without necessarily following a rigid sequence of stages.
5. **Critique of Davis's Cycle of Erosion**:--- King rejected Davis’s concept of sequential stages of youth, maturity, and old age in landscape evolution. Instead, he advocated for a more process-oriented approach, arguing that erosion and landform development are influenced by specific environmental and geological conditions rather than a universal "cycle."
6. **Recognition of Climatic and Lithological Controls**:--- King emphasized the importance of climate and rock type in controlling geomorphic processes. For instance, arid regions experience processes like deflation and sheet erosion, whereas humid regions are dominated by fluvial incision and chemical weathering.

### **Importance of King’s Ideas:**

King's theories are particularly relevant in understanding landscapes in arid and semi-arid environments, such as the African veldt and Australian outback. His ideas challenged the rigid cyclical models of earlier geomorphologists and emphasized the role of regional and environmental factors in shaping the Earth's surface. His concept of scarp retreat and pediplanation remains influential in modern geomorphology.

***35. Glacial Processes in landforms development-***

Glacial processes are powerful agents of landform development, operating in areas where ice accumulates and flows as glaciers. These processes involve the movement of ice, erosion, transportation, and deposition, shaping distinct landscapes. Glacial landforms can be categorized into **erosional** and **depositional** features, reflecting the dual nature of glacial activity.

#### **1. Erosion**

Glaciers erode the landscape primarily through two mechanisms:

* **Plucking**: As glaciers move, they freeze onto the bedrock, pulling away fragments as the ice advances.
* **Abrasion**: Rock fragments embedded in the glacier act like sandpaper, grinding and smoothing the underlying bedrock, leaving striations (grooves) and polish.

These processes create characteristic erosional landforms:

* **Cirques (Corries)**: Bowl-shaped depressions where glaciers originate.
* **Arêtes**: Sharp ridges formed between two adjacent cirques.
* **Horns**: Isolated, pyramid-shaped peaks formed by the erosion of multiple cirques.
* **U-shaped Valleys**: Deep valleys with steep walls and flat floors, created as glaciers carve through V-shaped river valleys.
* **Hanging Valleys**: Smaller tributary valleys left "hanging" above the main valley after the glacier retreats.
* **Roche Moutonnée**: Asymmetric bedrock features with a smooth, sloping side (abrasion) and a steep, jagged side (plucking).

#### **2. Transportation**

Glaciers transport debris (glacial till) picked up during erosion. The load is carried:

* **On the surface**: Material from valley walls falls onto the glacier.
* **Within the ice**: Rocks and debris are embedded in the moving glacier.
* **At the base**: Sediments are dragged along as the glacier slides over the bedrock.

#### **3. Deposition**

When glaciers melt, they deposit sediments carried along their path. Depositional processes create various landforms:

* **Moraines**: Accumulations of glacial debris deposited at different points:
  + **Terminal Moraines**: Mark the furthest advance of a glacier.
  + **Lateral Moraines**: Form along the sides of a glacier.
  + **Medial Moraines**: Form where two glaciers merge, combining their lateral moraines.
  + **Ground Moraines**: Spread out as a thin layer of till beneath the glacier.
* **Drumlins**: Streamlined, elongated hills of till, oriented parallel to the direction of glacier movement.
* **Eskers**: Sinuous ridges formed by sediment deposition in subglacial meltwater channels.
* **Kames**: Irregular mounds of sediment deposited by meltwater.
* **Erratics**: Large boulders transported by glaciers and deposited far from their source.
* **Outwash Plains**: Flat areas of sand and gravel deposited by meltwater streams beyond the glacier.

#### **4. Meltwater Processes**

As glaciers melt, the resulting meltwater plays a role in shaping landforms:

* **Proglacial Lakes**: Formed in front of retreating glaciers.
* **Kettle Holes**: Depressions created when blocks of ice become buried in sediment and then melt.
* **Braided Streams**: Networks of intertwined channels formed by high sediment loads carried by glacial meltwater.

### **Role of Glacial Processes in Shaping Landscapes**

* Glaciers carve rugged mountainous landscapes, such as those in the Himalayas or the Alps.
* They create distinctive depositional plains like the Northern European Plain.
* Post-glacial features like fjords (drowned glacial valleys) and tarns (lakes in cirques) add unique characteristics to landscapes.
* Glaciation has left lasting impacts on continental regions (e.g., the Great Lakes in North America) and shaped vast areas through ice sheet activity.

Glacial processes are critical for understanding past climatic conditions, as glacial landforms serve as records of historical glaciations and climate change.

***36. Aeolian Processes in landforms development- (Wind in Arid Region)***

**Aeolian processes** are geomorphic processes involving wind activity, which shape landforms primarily in arid, semi-arid, and coastal regions. These processes include **erosion**, **transportation**, and **deposition** by wind, creating distinct features that are often associated with deserts, sand dunes, and dry lake beds.

#### **1. Erosion**

Wind erodes the surface through two main mechanisms:

* **Deflation**: The removal of loose, fine particles like sand, silt, and clay from the ground, leaving coarser material behind. This process can create features such as:
  + **Deflation Hollows**: Depressions in the ground caused by extensive removal of fine particles.
  + **Desert Pavements**: Surfaces covered by closely packed gravel or stones left behind after finer particles are blown away.
* **Abrasion**: Sand particles carried by wind act like a natural sandblaster, wearing down rock surfaces. Abrasion is responsible for:
  + **Yardangs**: Streamlined ridges or rock features aligned parallel to prevailing wind direction.
  + **Ventifacts**: Rocks with polished, faceted surfaces sculpted by wind-driven sand.

#### **2. Transportation**

Wind carries sediment in several ways, depending on particle size and wind strength:

* **Suspension**: Fine particles like silt and clay are carried over long distances, often creating atmospheric dust storms.
* **Saltation**: Sand grains bounce along the surface in short hops, which is the primary mode of sand transport.
* **Creep**: Larger particles roll or slide along the ground, pushed by wind or impacted by saltating grains.

#### 3. **Deposition**

When the wind's velocity decreases, it loses the energy needed to carry sediment, leading to deposition. This process creates various depositional landforms:

* **Sand Dunes**: Mounds or ridges of sand formed by wind deposition. Different types of dunes develop based on wind direction, sand supply, and vegetation:
  + **Barchan Dunes**: Crescent-shaped dunes with horns pointing downwind, formed in areas with limited sand supply and unidirectional winds.
  + **Transverse Dunes**: Long ridges perpendicular to prevailing wind, formed where sand is abundant.
  + **Linear (Seif) Dunes**: Long, narrow dunes aligned with the wind direction.
  + **Star Dunes**: Multi-armed dunes formed in areas with variable wind directions.
* **Loess Deposits**: Extensive blankets of fine, wind-blown silt, often forming fertile soils in areas like the Loess Plateau in China or parts of the U.S. Midwest.
* **Sand Sheets**: Flat expanses of sand formed by deposition in areas with low wind velocity.

### **Aeolian Processes and Landform Types**

* **Desert Features**: Aeolian processes dominate arid regions, creating features like erg deserts (sand seas), playas (dry lake beds), and oasis depressions caused by deflation.
* **Coastal Features**: Wind shapes sand dunes along coastlines, providing natural barriers against wave erosion.
* **Agricultural Regions**: Loess deposits, though aeolian in origin, are some of the most agriculturally productive soils globally.

### **Significance of Aeolian Landforms**

Aeolian processes play a critical role in landscape development by:

* Modifying surface features, especially in arid and semi-arid environments.
* Acting as indicators of climatic conditions (e.g., past and present wind patterns, aridity).
* Contributing to sediment redistribution, which affects ecosystems and human activities.

These processes and the resulting landforms are key components of desert geomorphology and are important for understanding Earth's climatic and geological history.

Bottom of Form

***37. Slope Forming Processes-***

Slope-forming processes refer to the various mechanisms that shape the gradients and forms of slopes, primarily in response to geological, climatic, biological, and human influences. These processes can be broadly classified into two categories: **endogenic (internal forces)** and **exogenic (external forces)**.

### 1. **Endogenic Processes**

These processes originate from within the Earth and affect slope formation indirectly through tectonic and volcanic activities.

* **Tectonic Activity**: Uplift or subsidence caused by plate movements creates initial slope configurations. For example:
  + Mountain formation through folding and faulting.
  + Rift valleys and escarpments from normal or reverse faulting.
* **Volcanism**: Lava flows, volcanic cones, and pyroclastic materials create steep and irregular slopes.

### **2. Exogenic Processes**

These are external forces that directly shape and modify slopes over time through weathering, mass wasting, and erosion.

#### A. **Weathering**

Weathering processes break down rocks and create materials that contribute to slope evolution.

* **Physical Weathering**: Disintegration of rock due to freeze-thaw cycles, thermal expansion, and pressure release.
* **Chemical Weathering**: Alteration of rock minerals by processes like oxidation, carbonation, and hydrolysis.
* **Biological Weathering**: Roots of plants and activities of organisms contributing to rock breakdown.

#### B. **Mass Wasting**

Mass wasting involves the downslope movement of rock, soil, or debris under gravity. The rate and nature of movement depend on factors like slope gradient, material type, and water content.

* **Creep**: Slow, gradual movement of soil and regolith.
* **Landslides**: Rapid movement of large rock or soil masses.
* **Rockfall**: Sudden detachment of rocks from a steep slope.
* **Debris Flow**: Rapid flow of water-laden debris.

#### C. **Erosion**

Erosion transports weathered material downslope via agents such as water, wind, and ice.

* **Fluvial Erosion**: Water cuts into slopes, forming valleys and gullies.
* **Aeolian Erosion**: Wind modifies slopes in arid regions by abrasion and deflation.
* **Glacial Erosion**: Ice carves U-shaped valleys, creating steep slopes.
* **Coastal Erosion**: Wave action shapes cliffs and coastal slopes.

### 3. **Biological and Anthropogenic Influences**

* **Vegetation**: Stabilizes slopes by binding soil, but can also contribute to weathering through root action.
* **Human Activity**: Mining, deforestation, construction, and agriculture accelerate slope degradation or modification.

### 4. **Types of Slope Forms**

Slope forms evolve based on the interplay of the above processes:

* **Convex Slopes**: Shaped by creep or weathering.
* **Concave Slopes**: Formed by fluvial erosion and deposition.
* **Rectilinear Slopes**: Characterized by uniform gradients, often due to mass wasting.

Understanding slope-forming processes is essential for mitigating natural hazards and managing landscapes effectively. Let me know if you'd like more detail on specific processes!

***38. Normal Cycle of Erosion by W.M. Davis***

Basic assumption of w.M. Davis

* 1. Homogeneous Lithology
  2. Rapid uplift and no erosion during uplift
  3. Commencement of erosion after upliftment ends
  4. Long crustal stability
  5. Area should be humid tropics.

**Three stages--- Youth, Mature, and Old**

**CHARACTERISTICS OF YOUNG LANDSCAPE**

1. Few Consequent Streams with few Large Tributaries.
2. Headward Erosion by Small Tributaries and Gullies
3. Development of V-shaped Valleys
4. Lack of Floodplain Development
5. Interstream Tracts — wide and poorly drained; development of Lakes and Swamps
6. Waterfalls and Rapids exist where stream crosses resistant rock beds
7. Stream Meandering may exist on flat, undissected initial surface but are closely confined
8. Maximum Altitude → Maximum Potential Energy

**CHARACTERISTICS OF MATURE LANDSCAPE**

1. Valleys extend → well-integrated Drainage system

2. Adjustment of streams with lithology and structure →Existence of Longitudinal Tributaries along belts of weak rock

3. Stream divides sharp and ridge-like →minimum interstream uplands → Maximum Relief at early Maturity

4. Attainment of Profile of Equilibrium by master Streams

5. Elimination of lakes and waterfalls

6. Wide Floodplains at Valley floors

7. Conspicuous Meanders – free to shift positions over floodplains

8. Width of the Valley floors do not exceed the width of the Meander belts

9. Maximum possible Relief

10. Topography consists much of Slopes of Hillsides and Valley sides

**CHARACTERISTICS OF OLD LANDSCAPE**

1.Tributaries – less numerous than in Maturity but more than in Youth

2.Valleys – extremely broad & gently sloping laterally and longitudinally

3.Extensive Floodplains with broadly Meandering Streams

4.Valley widths – greater than those of the Meander belts

5.Stream divides reduce in heights, gently sloping→Residual hills— MONADNOCKS

6.Lakes, Swamps, Marshes on floodplains, not on interstream areas

7.Mass Wasting – dominant over fluvial processes

8.Extensive areas are or at near BASE LEVEL OF EROSION

***39. THE ARID CYCLE OF EROSION***

**Important Terms Associated with Arid Topography:**

For better understanding of the landforms produced in arid and semi-arid regions by mechanical weathering and water action, some of the resultant features are discussed below. Without a proper understanding of these landforms the arid cycle of erosion cannot be comprehended fully.’

**Badiand Topography: --**In arid regions occasional rainstorms produce numerous rills and channels which extensively erode weak sedimentary formations. Ravines and gullies are developed by linear fluvial erosion leading to the formation of badiand topography.

**Bolsons and Playas: --**The intermontane basins in dry regions are generally known as bolsons. Three unique landforms viz. pediments, bajadas and playas are typically found in these basins. Small ephemeral streams flow into bolsons, where water is accumulated to form playas. They are called khabari and mamlaha in Arabian deserts while they are called shafts in the Sahara Desert. After the evaporation of water, salt-covered playas are called salinas.

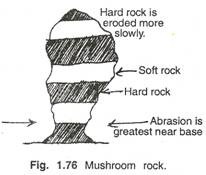
**Bajada: ---**Bajadas are moderately sloping depositional plains located between pediments and playa. Several alluvial fans coalesce to form a bajada. The slope gradient in its upper part ranges from 8° to 10° whereas it reaches 1° to zero at the bottom.

**Pediments:** The term pediment was used for the first time by G.K. Gilbert in 1882. In form and function there is no difference between a pediment and an alluvial fan; however, pediment is an erosional landform while a fan is a constructional one. A true pediment is a rockcut surface at the foot of mountains. Pediment is a slope of derivation or transportation as thin veneers of debris flow down the slope extending for several kilometres in length.

**Erosional Works of Wind:**

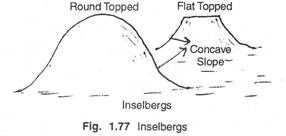
The wind or aeolian erosion takes place in the following three ways, viz. (1) deflation, (2) abrasion or sandblasting, and (3) attrition. Deflation refers to the process of removing, lifting and carrying away dry, unsorted dust particles by winds. It causes depressions known as blow outs. When wind loaded with sand grains erodes the rock through mechanisms like abrasion, fluting, grooving, pitting and polishing, the combined impact of these mechanisms is called abrasion or sandblasting. Attrition refers to wear and tear of the sand particles while they are being transported by wind mainly by processes like saltation (sands and gravels moving through bouncing, jumping and hopping) and surface creep (involving movement of comparatively larger particles along the surface).

**Erosional Landforms:** Following are the major landforms produced by wind erosion.

**[](http://cdn.yourarticlelibrary.com/wp-content/uploads/2014/10/clip_image010.jpg)Deflation basins: --**They are also known as blow-outs and desert hollows varying in size from the very small (“buffalo wallows’ of the American Great Plains) to the extremely large depressions like ‘pang kiang1 of the Mongolian desert. In areas where deflation has been active and the desert surface is filled with loose fragments, lag deposits are found. Thus desert pavements are formed as the pebbles roll and jostle together.

**Mushroom rocks: --**The rocks have broad upper portion in contrast to their narrow base and thus resemble an umbrella or mushroom. Mushroom rocks are also called pedestal rocks or pilzfelsen (J. Walther). They are the products of abrasion from all sides caused by variable directions of wind. Such features are called gara in the Sahara and pilzfelsen in Germany.

**Inselbergs: --**The term was first used by Passarge in 1904 to delineate relict hills of South Africa. There has been a debate regarding the origin of these inselbergs or bornhardts. (Fig. 1.77)

**[](http://cdn.yourarticlelibrary.com/wp-content/uploads/2014/10/clip_image011.jpg)Demoiselles: --**These are rock pillars which stand as resistant rocks above soft rocks as a result of differential erosion of hard and soft rocks.

**Zeugen: ---**Flat-topped rock masses resembling a capped inkpot, zeugens stand on softer rock pedestals like mudstone, shale, etc. Zeugens are formed in desert areas characterised by a high range of temperature. The alternate freeze and thaw of moisture results in expansion and contraction which ultimately disintegrates rocks along the joints.

**Yardangs: ---**These steep-walled rock ridges are segregated from one another by grooves, corridors or passageways found on less resistant rocks in deserts. The yardangs have an average height of eight metres although yardangs of 60 m height are found in the Lutt desert of Iran. Yardangs are formed where hard and soft rocks are placed vertically in alternate bands parallel to each other. Yardangs have been named ‘cockscomb’ by A. Holmes.

**Ventifacts and Dreikanter: --**Ventifacts are formed when faceted rock boulders, cobbles and pebbles are subjected to abrasion by prolonged wind erosion. Dreikanters are formed when a ventifact is abraded on as many as three sides. Boulders having two abraded facets are known as zweikanter.

**Stone lattice: --**In deserts, rocks made of varying compositions and resistance are converted into pitted and fluted surfaces as powerful winds charged with rock particles remove weaker sections of the rocks.

**Wind bridges and windows: --**Powerful wind continuously abrades stone lattices, preating holes. Sometimes the holes are gradually widened to reach the other end of the rocks to create the effect of a window—thus forming a wind window. Window bridges, are formed when the holes are further widened to form an arch-like feature.

**Depositional Landforms:** Landforms due to depositional force of wind. These are as follows.

**Ripple Marks: --**These are depositional features on a small scale formed by saltation. Ripples are of two types: (i) transverse ripples and (ii) longitudinal ripples.

**Sand dunes: --**Sand dunes are heaps or mounds of sand found in deserts. Generally their heights vary from a few metres to 20 metres but in some cases dunes are several hundred metres high and 5 to 6 km long. The formation of sand dunes requires (i) abundant sand, (ii) wind of high velocity, (iii) obstacles such as trees, bushes, forests, rock outcrops, walls boulders against which dunes may settle, and (iv) ideal places i.e., dune complex, dune chain or dune colony. Dunes formed due to obstacles like bushes, walls etc., are called nebkhas where dunes formed in the leeside of desert depressions are called lunettes.

**Loess:---** Loess is loose, unstratified, non- indurated, buff-coloured fine sediments which are deposited at places far from their source of origin. Loess is of two types: (i) desert loess and (ii) glacial loess. The most extensive loess deposits occur in North China where they are spread over 7, 74,000 sq.km. The loess terrain has been converted into badland topography as a result of erosion. Loess is known as limon in France and Belgium. In North America it is called adobe.

### ***40. Glacial Cycle of Erosion:***

#### Youth: --The stage is marked by the inward cutting activity of ice in a cirque. Aretes and horns are emerging. The hanging valleys are not prominent at this stage.

#### Maturity: --- The valley glacier gets transformed into trunk glacier and hanging valleys start emerging. The opposite cirques come closer and the glacial trough acquires a stepped profile which is regular and graded.

**Old Age:---** Emergence of a ‘U’-shaped valley marks the beginning of old age. An outwash plain with features such as eskers, kame terraces, drumlins, kettle holes etc. is a prominent development. The opposite cirques coalesce and the summit heights are greatly reduced. Mountain tops become rounded.

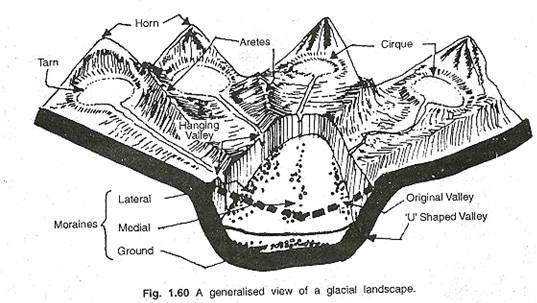
# The Glacial Landforms

A glacier is a moving mass of ice at speeds averaging between 30 to 40 cm and 15 to 18 metres per day. It originates at high altitudes due to low temperatures and high orographic precipitation. Glaciers are of four types, viz. continental glaciers, ice caps, piedmont glaciers and valley glaciers. The continental glaciers are found in the Antarctica and in Greenland. The biggest continental ice sheet in Iceland, for example, has an area of 8,450 square kilometres, and the thickness of its ice is 1,000 metres. Ice caps are the covers of snow and ice on mountains from which the valley or mountain glaciers originate. The piedmont glaciers form a continuous ice sheet at the base of mountains as in southern Alaska.

The valley glaciers, also known as Alpine glaciers, are found in higher regions of the Himalayas in our country and all such high mountain ranges of the world. While the continental ice masses covering thousands of square kilometres and thousands of metres thick move outward in all directions from their central portions, the valley glaciers move down the mountain slope towards lower regions. There is a great variation in their size. The largest of Indian glaciers occur in the Karakoram Range, viz. Siachen (72 km), while Gangotri in Uttar Pradesh (Himalayas) is 25.5 km long and many others are as small as 5-10 km in different parts of the range.

**The conditions favouring the formation of snow fields above the snowline are:**

(i) the gentle slopes from where they cannot easily be swept off by wind or break off the slope as an avalanche, and (ii) the hollows or localities sheltered from direct sun. A glacier is charged with rock debris which range from highly pulverised rock flour to huge angular boulders of fresh rock, obtained by freeze- thaw and plucking and which are used for erosional activity by moving ice. A glacier during its lifetime creates various landforms which may be classified into erosional and depositional landforms.

**[](http://www.geographynotes.com/wp-content/uploads/2014/10/clip_image0025.jpg)**

### **Erosional Landforms:**

#### 1. Cirque/Corrie: --- Is an amphitheatre-shaped hollow basin cut into a mountain ridge. It has steep sided slope on three sides, an open end on one side and a flat bottom. When the ice melts, the cirque may develop into a tarn lake.

#### 2. Glacial Trough: ---Is an original stream-cut valley, further modified by glacial action? Step- formation takes place at maturity; otherwise it is an ungraded and irregular feature.

#### 3. ‘U’ Shaped Valley: ---Is another typically glacial feature. Since glacial mass is heavy and slow moving, erosional activity is uniform—horizontally as well as vertically. A steep sided and flat bottomed valley results, which has a ‘U’ shaped profile.

#### 4. Hanging Valley:-- Is formed when smaller tributaries are unable to cut as deeply as bigger ones and remain ‘hanging’ at higher levels than the main valley as discordant tributaries. This may happen due to glacial tilting or faulting.

#### 5. Arete: -- Is a steep-sided, sharp-tipped summit with the glacial activity cutting into it from two sides

**6. Horn** is a ridge that acquires a ‘horn’ shape when the piedmont glacier surrounds a summit.

**7. Fjord** is formed as a steep-sided narrow entrance-like feature at the coast where the stream meets the coast. Fjords are common in Norway, Greenland and New Zealand.

### **Depositional Landforms:**

#### 1. Outwash Plain: --- When the glacier reaches its lowest point and melts, it leaves behind a stratified deposition material, consisting of rock debris, clay, sand, gravel etc. This layered surface is called till plain or an outwash plain and a downward extension of the deposited clay material is called valley train.

#### 2. Esker:-- is a winding ridge of unassorted depositions of rock, gravel, clay etc. running along a glacier in a till plain. The eskers resemble the features of an embankment and are often used for making roads. If the melting of glacier has been punctuated, it is reflected in a local widening of the esker and here it is called a beaded esker.

#### 3. Kame: --Terraces are the broken ridges or unassorted depositions looking like hummocks in a till plain.

#### 4. Drumlin: --Is an inverted boat-shaped deposition in a till plain caused by deposition. The erosional counterpart is called a roche moutonne.

#### 5. Kettle Holes: -- Can be formed when the deposited material in a till plain gets depressed locally and forms a basin.

#### 6. Moraine: Is a general term applied to rock fragments, gravel, sand, etc, carried by a glacier. Depending on its position, the moraine can be ground, lateral, medial or terminal moraine. The material dropped at the end of a valley glacier in the form of a ridge is called the terminal moraine. Each time a glacier retreats, a fresh terminal moraine is left at a short distance behind the first one.

The material deposited at either of its sides is known as lateral moraine. When two glaciers join, their lateral moraines also join near their confluence and are called medial moraines. Many Alpine pastures in the Himalayas like the Margs of Kashmir occupy the sites of morainic deposits of old river valleys. The excessive load that cannot be carried forward by a glacier is deposited on its own bed or at the base and appears as what is known as ground moraine.

***41. Distinguish between peneplain and Pediplain-***

(1)The term peneplain was adopted by WM Davis to describe an almost featureless plain in humid region. On the other hand the term pediplain was used by LC King to describe an almost featureless plain in Arid or semi arid region.

(2)Peneplain is the end-product of normal cycle of erosion and it is hypothetical. On the other hand the pediplain is the end-product of Arid cycle of erosion.

(3)In a pepeplain the rivers have reached their grade or base level, but in pediplain the rivers have their carrying capacity.

(4)In peneplain there are some hilly uplands of low height that lie scattered here and there which was so hard and resistant. On the other hand in pediplain there are low relief with steepside residual hills.

(5)The important feature of peneplain is monadnock but it is Insel burge in pediplain.

(6)In peneplain there is a deep cover of weathered debris and soil, on the other hand pediplain is the result of pedimentation.

(7)Examply of peneplain is are- Southern Findland, Central plains of Russia, Eastern Englan, Part of Amozan basin, upper Mississipi valley, Aravalli region of Indian etc. Tnhe Examples of pediplain are South Africam Brazsil, penesular India, Australia, Antarctica etc.

Process involved in the formation of Peneplain-

As we know that peneplain is a low and gently undulating surface of subacrial erosion. Here subaerial erosion refers to the denudation process of running water. Chemical weathering and mass-wasting are largely responsible for peneplain development. It is also influenced by diastrophic conditions. Peneplains are not produced primarily by lateral stream erosion but by down-wasting of ingterstream tracts. Here alluviam is not extensively present on peneplains.

According to WM Davis peneplain is an aresa of low undulating relief with convex, gently graded ingterstream tracts sloping down to broad valley floors. To attained this stage, it is necessary a sufficient length of time. During this period the landform pass throw youth, mature and old stage. The sequence of erosion leadng to a peneplain can be explained as followe-

1.In the youth stage steep valley-side slopes developed, Therefore, the rate of debris production is high and the size of debris over steep slopes is also large, The transported debris accumulate at the beak of slopes until the slope profile attains a balance between the rate debris production and its transport in the down slope direction.

2. In the mature stage, both the slope and size of weathered debris decrease but the thickness of waste materal increase.

3.In the old stage, all slopes become gentle and the transport of debris rarely fine in texture. A thick cover of waste products accumulates over gentle slopes. The river bed become too gentle wide which Davis called it peneplain.

**Process involved in the formation of pediplain**

The term pediplain was proposed by LC King ater study the African landscape. It is the end-product of Arid cycle of erosion characterized by low slope angles, It is the result of pedimentation dominance of running water. The pediments are produced by wash, mudflows and lateral planation. Pediments are produced by the erosive power of water flowing occasionally in arid areas. By this process mountain are reduced and convert almost plain surface. Therefore, pediplain is a rack-cut surface the maximum thickness of sediment cover above cut rack may be 4 to 6 meters. In the plain section the rise is about 2 to 20 meters. In South Africa, Braxil, Australia, Antarctica, pediment like surface is well-marked. In India this type of surface is also seen in Chantanagpur, Rayslaseema and Tamilnadu.

***42. Concept of Relief:-***

**Mountains:-** Refers to a mass of land considerably higher as compared to its surroundings and of greater altitude as compared to a hill. Mountains are the most prominent features of the earth’s relief of the earth, which rise above the general height of a country. It is taken that a particular mountain must be more than 2000ft. in height and at least half of its surface must consist of steep slope. Mountains are three types- Fold Mountain, Block Mountain and Volcanic Mountain. Fold Mountains are created by **organic movement** of earth. The Himalaya, The Rokies, The Andis, are the example of Fold mountain. All are composed of sedimentary rocks. Block Mountains are formed due to upliftment of certain area.

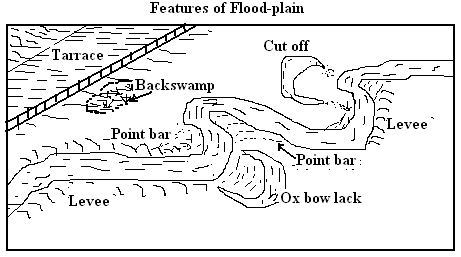
**Plateau:-** Refers to an extensive level area of elevated land. It is also called highland. Many hills are seen in plateau. Waterfall, ‘V’ shape valley is common features in plateau region. Often the plateau is traversed by rivers and mountain range. A plateau is a flat, elevated landform that rises sharply above the surrounding area on at least one side.

There are two kinds of plateaus: dissected plateaus and volcanic plateaus. A dissected plateau forms as a result of upward movement in the Earth’s crust. The uplift is caused by the slow collision of tectonic plates. The Colorado Plateau, in the western United States, has been rising about .03 centimeter (.01 inch) a year for more than 10 million years. The Meghalaya, Karbi plateau are the example.

A volcanic plateau is formed by numerous small volcanic eruptions that slowly build up over time, forming a plateau from the resulting lava flows. The North Island Volcanic Plateau covers most of the central part of the North Island of New Zealand. This volcanic plateau still has three active volcanoes: Mount Tongariro, Mount Ngauruhoe, and Mount Ruapehu.

**Hills:-** Refers to a small portion of the earth’s surface that is elevated above its surroundings, of lower altitude than a mountain. In general, an eminence is not considered a mountain unless its elevation from foot to summit is well over 300m. In North-East India we have seen Karbi hill, Naga hill, Barail hill, etc.

**Foothills:-** Foothills refers to the transitional line of hills, lying between mountain and plain. It is almost parallel to a main range of mountains and plain, due to either of the intermediate zone of uplift or of active denudation. On the other hand, foothill can be said lower portion of hill or mountain. The foothills are dissected by rivers, and its slope is gentle.

**Valleys:-** Refers to a long, narrow depression in the earth’s surface, generally having a fairly regular downward slope. A river or stream generally flows through it, having carved it out from the surface rocks, and it is then called a river valley. When a valley is young, it is narrow and its sides are steep. If the land is high, it has a steep gradient and the valley is somewhat V-shaped in cross-section. When a valley is mature then it is wider, its sides are often gentler. An old valley is very wide and it has a broad flood-plain.

**Plains:-** Refers to an extensive areas of level or gently undulating land found in low altitude. Plains may be formed in a number of ways, and are generally named accordingly. For example- Alluvial plains created by running water near mountain or hills, Coastal plain created by sea waves near sea or ocean, flood plains created by river in lower portion of river.

**Flood Plain:-** A flood plain is the most common depositional feature created by all sizes of river. They may be very large or just small brooks. The alluvial in a flood-plain is composed of several kinds of deposit. Principally, the flood plain is built up laterally by channel deposits in a coalescing series of bars composed of sand and gravel. It is also built up vertically by aggradations of over bank deposits during flooding. Floods deposit coarse materials as levees near the channel and finer silt and clay over the rest of the flood-plain surface. There are several features in a flood plain. The common features seen in flood-plain are shown in the figure below.

***43. Concept weathering-***

**Weathering** refers to the process by which rocks and minerals at or near the Earth’s surface are broken down into smaller particles or altered chemically, biologically, or physically without being transported. It is a critical part of landscape evolution and contributes to soil formation and the shaping of Earth’s surface.

### **Types of Weathering**

**Physical (Mechanical) Weathering**--Physical weathering involves the breakdown of rocks into smaller pieces without changing their chemical composition. This process is most common in environments with temperature fluctuations or physical stresses.

**Frost Action (Freeze-Thaw)**: Water enters cracks, freezes, and expands, causing the rock to split.

**Thermal Expansion**: Repeated heating and cooling cause the rock to expand and contract, leading to fracturing.

**Pressure Release (Exfoliation)**: Removal of overlying materials reduces pressure, causing rock layers to peel away like onion layers.

**Abrasion**: Rocks are worn down by friction or collision with other rocks, often in riverbeds, glaciers, or deserts.

**Chemical Weathering**---- Chemical weathering alters the mineral composition of rocks through chemical reactions, leading to their breakdown. This type is most effective in warm, wet climates.

**Oxidation**: Reaction of oxygen with minerals, especially iron, forming rust-like substances.

**Carbonation**: Carbon dioxide dissolves in water to form carbonic acid, which reacts with carbonate rocks like limestone, creating caves or karst landscapes.

**Hydrolysis**: Water reacts with minerals, leading to the formation of new, softer minerals. For example, feldspar transforms into clay.

**Solution**: Soluble minerals, like halite, dissolve directly in water.

**Biological Weathering**--- Biological weathering involves the role of living organisms in breaking down rocks. This can occur through physical or chemical mechanisms.

**Root Action**: Plant roots grow into cracks in rocks, exerting pressure and causing the rock to split.

**Organic Acids**: Organisms like lichens and mosses produce acids that chemically alter rock minerals.

**Animal Activity**: Burrowing animals expose rocks to air and water, accelerating weathering.

### **Factors Influencing Weathering**

1. **Climate**: Temperature and precipitation greatly affect the rate and type of weathering.
   * Warm, humid climates favor chemical weathering.
   * Cold climates favor physical weathering (e.g., freeze-thaw cycles).
2. **Rock Type**: Different minerals weather at different rates.
   * Igneous rocks are generally more resistant than sedimentary rocks.
   * Limestone weathers rapidly due to carbonation.
3. **Topography**: Steep slopes facilitate faster removal of weathered material, exposing fresh rock to further weathering.
4. **Time**: Longer exposure leads to more extensive weathering.

### **Importance of Weathering**

* **Soil Formation**: Weathering produces the mineral component of soil.
* **Landform Development**: Processes like karst topography are direct results of weathering.
* **Ecosystem Support**: Weathering releases essential nutrients like calcium, potassium, and phosphorus.

***44. Concept of Mass Wasting-***

**Mass wasting**, also known as **mass movement**, refers to the downslope movement of soil, rock, and debris under the direct influence of gravity. Unlike erosion, which involves a transporting medium like water, wind, or ice, mass wasting occurs without the aid of these external agents. It plays a significant role in shaping landscapes, especially in hilly and mountainous regions.

### **Key Characteristics of Mass Wasting**

1. **Gravity-Driven**: The primary driving force is gravity, acting on materials loosened by weathering.
2. **Varied Speeds**: It can occur rapidly (e.g., landslides) or slowly (e.g., soil creep).
3. **Triggering Factors**: Though gravity is the main force, other factors like water, earthquakes, and human activities often trigger mass wasting.

### **Factors Influencing Mass Wasting**

1. **Slope Gradient**: Steeper slopes have a higher likelihood of mass wasting due to greater gravitational pull.
2. **Material Strength**: The cohesion and friction between particles determine slope stability. Weak or weathered materials are more prone to movement.
3. **Water Content**:
   * Small amounts of water increase cohesion (surface tension between particles).
   * Excess water reduces friction and adds weight, making slopes unstable.
4. **Vegetation Cover**: Vegetation roots bind soil and stabilize slopes. Removal (e.g., deforestation) increases vulnerability.
5. **Earthquakes**: Seismic activity can trigger sudden mass wasting events by shaking and loosening materials.
6. **Human Activity**: Construction, mining, and road building often destabilize slopes.

### **Types of Mass Wasting**

Mass wasting is categorized based on the type of material involved and the speed and nature of movement:

1. **Creep**:
   * **Description**: Slow, imperceptible movement of soil and regolith.
   * **Causes**: Freeze-thaw cycles, wetting and drying.
   * **Effects**: Curved tree trunks, tilted poles, and sagging fences.
2. **Slump**:
   * **Description**: Rotational movement of a mass of soil or rock along a curved surface.
   * **Appearance**: Forms a stair-step or terraced slope.
   * **Common in**: Areas with soft clay or silt layers.
3. **Landslide**:
   * **Description**: Rapid movement of rock or debris along a well-defined plane.
   * **Triggering Factors**: Heavy rainfall, earthquakes, or volcanic eruptions.
4. **Rockfall**:
   * **Description**: Sudden free-fall of detached rocks from a steep slope or cliff.
   * **Triggering Factors**: Frost wedging, earthquakes, or undercutting.
   * **Effects**: Forms talus slopes at the base of cliffs.
5. **Debris Flow (Mudflow)**:
   * **Description**: Rapid flow of a mixture of soil, rock, and water.
   * **Triggering Factors**: Intense rainfall or volcanic activity (lahars).
   * **Common in**: Steep slopes with loose materials and little vegetation.
6. **Earthflow**:
   * **Description**: Slow to rapid flow of fine-grained soil saturated with water.
   * **Appearance**: Often resembles a lobe or tongue-shaped mass.
7. **Avalanche**:
   * **Description**: Rapid downslope movement of snow, ice, and debris.
   * **Triggering Factors**: Heavy snowfall, wind loading, or human activity.

### **Significance of Mass Wasting**

1. **Landscape Evolution**: Shapes valleys, cliffs, and slopes over time.
2. **Hazards**: Can cause loss of life and property, especially in populated areas.
3. **Soil Redistribution**: Contributes to soil movement and deposition in lower-lying areas.
4. **Ecosystem Impact**: Influences vegetation patterns and water flow in affected areas.

**QUESTIONS:-**

1. Distinguish between peneplain and pediplan. -3

2. Explain the prosesses involved in the formation of peneplain and pediplain with examplene.—6

3. Classify the geomorphic processes. –3

4. Describe the landforms and processes associated with the development of faulted topography—8

5. Devine the term isostasy. Discuss how the Isostasy theory helps interpreting the major relief features of the earth.—8

6. Discuss the nature and scope of geomorphology.—5

7. Discuss recent trends in the study of geomorphology. ---6

8. Write short note of the views of W. Penck on land form development.—6

9. Discuss the Mass wasting processes. --- 6

10. Write the concept of plate tectonic. --- 6

11. Write short note on weathering—5

12. Write short note on erosion—5

13.Discuss the different types of mass wasting—5

14. Discuss the views W.M. Davis on landform development. – 5

15. Discuss the mechanism and phases of formation of folded mauntains. – 6

16. Different the term Geodynamics. – 5

17. Write the concept of continental crust. – 5

18. Discuss the Wegner’s views on disintegration of Pangaea. – 6

19. Describe with neat diagrams the structure and composition of Earth’s crust. –10

20. Mention the major plats of the Earth with suitable diagram.—8

21. Analysis the processes of land form development under Arid Cycle of erosion. -10

22. Describe the mountain building process as explained by Kober. – 10

23. write short note on carust landforms and Hanging Valley. – 5

24. What is the average density of the earth? -1

25. Give the name of the norther block of the Pangaea. – 1

26. Who was the first to proposed the term Isostasy? – 1

27. With which theory in geomorphology the term Randketten is associated? – 1

28. Bergschrund is a feature of -------------- topography. –1

29. Conglomerate is a type of ----------------.

30. Who discover Richter scale in 1935? - 1

31. Write the characteristics of Sima. – 3

32. What is Eustatism? – 3

33. what is steady State?- 1

34. Who coin the term stady state? – 1

35. Write the compositional characteristic of the Earth’s interior. – 5

36. Write the scope of Tropical Geomorphology. – 4

37. Distinguish between orogenic and epeiorgenic movements. – 5

38. Write the impact of earth quake. – 4

39. Residual hill in the desert region is known is -------------. 1

40. Write the processes of Chemical weathering. – 4

41. Who proposed the continental drift theory. –1

42. Barchan is associated with ------- topography. –1

43. Arête is the term associated with ----- topography. –1

44. Write short note on –(a). Inselberg, (b). Hanging valley, (c). Runoff. (d) Alluvial fan, (e) moraine. —4

45. Who proposed Normal Cycle of erosion theory/ --1

46. what is youngest folded mountain in India?

47. Mush room rocks created by the action of----------. –1

48. Write short note on – Sial layer/ Rift valley/ delta/ flood plain. – 3

49. Write the causes of earthquake and volcanos. – 6

50. Write the characteristics of land form in limestone region—6

51. Write the concept of Post- modern geomorphology. – 5

52. Write the development of Geomorphology after World War-II. – 5

53. Distinguish between Theoretical and Applied geomorphology. – 6

54. Distinguish between Fluvial and Glacial geomorphology. – 6

55. Write the name of erosional features of Aired region. – 3

56. Distinguish between Environmental and Palaeogeomorphology. – 6

57. Distinguish between rocks and minerals. – 6

58. Write the concept of Dynamic equilibrium. – 5

59. Write about the Aeolian process in land forms development.- 5

60. Write about the slope forming processes. – 5

61. Write two differences between Anticline and Syncline. -2

62. Write two differences between Sand Dunes and Loess. – 2

63. The zone of the earth’s interior which is mainly composed of silicate and magnesium. – 1

64. To which order of landform does the ocean belong?. 1

65. Distinguish between Stratified rock and Metamorphic rock. – 6

66. Write four name of erosional feature formed by river. – 2

67. Name two landform created by exogenetic forces. -1

68. Give an example of chemical weathering. -1

69. What are the three stages of cycle of erosion. – 2

70. State the meaning of endogenetic force. -2

71. What do you mean by order of landforms? In which order of landforms the continents and ocean basin are included? -2

72. Name four geomorphic features developed in fifferent stages of a Glacial cycle of erosion. -2

73. Mention any four process of physical weathering. -2

74. Mention the name of five geomorphic features developed due to wind erosion. – 5

75. Describe the geomorphic features formed due to erosional activity of glaciers.- 10

76. Who postulated the theory of continental drift.- 1

77. Name four folded mountain of the world. – 2

78. Mention the three waves of earthquake.- 2

79. What are the agents of exogenetic process.- 3

80. Write about the convection current theory of Holms.

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