

GEOMORPHOLOGY

Term 2 Grade 11



KEY TERMS:

- Topography – relief or the shape of the land
- Stratified rock – rock composed of layers or strata
- Bedding planes – planes separating layers of rock
- Landscapes – area with a number of landforms
- Plateau – large high lying area that is relatively flat
- Sheet wash – rainfall flowing over the land as a sheet
- Badlands – landscapes with narrow gullies and sharp ridges formed in arid climates

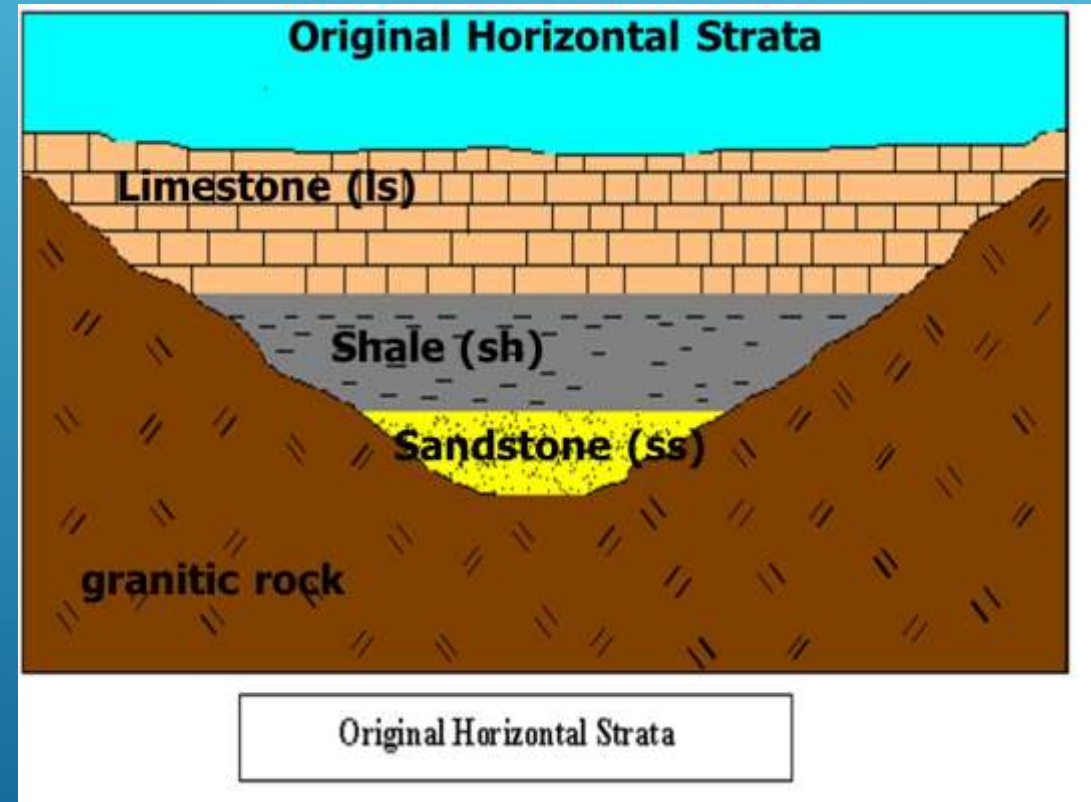
1. TOPOGRAPHY ASSOCIATED WITH HORIZONTALLY LAYERED ROCKS

- This topography is associated with stratified rocks.
- Horizontal layers of rock are found where sediments have been deposited and then uplifted without a change in their horizontal position.



CHARACTERISTICS OF HILLY LANDSCAPES AND BASALTIC PLATEAUS

- Hilly landscapes & basaltic plateaus develop in areas where rock strata are horizontal.
- The rock strata of these landscapes are uniformly (erode at a similar rate) resistant to erosion



1. HILLY LANDSCAPES

- Layers of horizontal sedimentary rock with uniform resistance to erosion form a steep hilly landscape.
- The climate of the area influences the nature of the slopes in hilly landscapes:
 1. Steep hills with rounded slopes form in humid climates as sheet wash takes place, rainfall runs down the slopes and removes surface material.
 2. Hills with narrow gullies and sharp ridges form in arid climates, slopes are steep and uneven. These landscapes are called badlands.

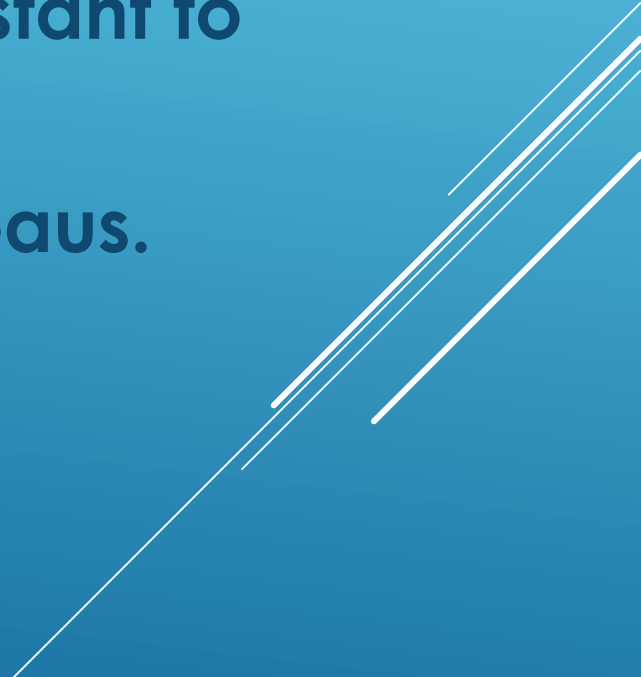


STEEP HILLS WITH ROUNDED SLOPES – HUMID CONDITIONS



BADLANDS – ARID CLIMATES

2. *BASALTIC PLATEAUS*

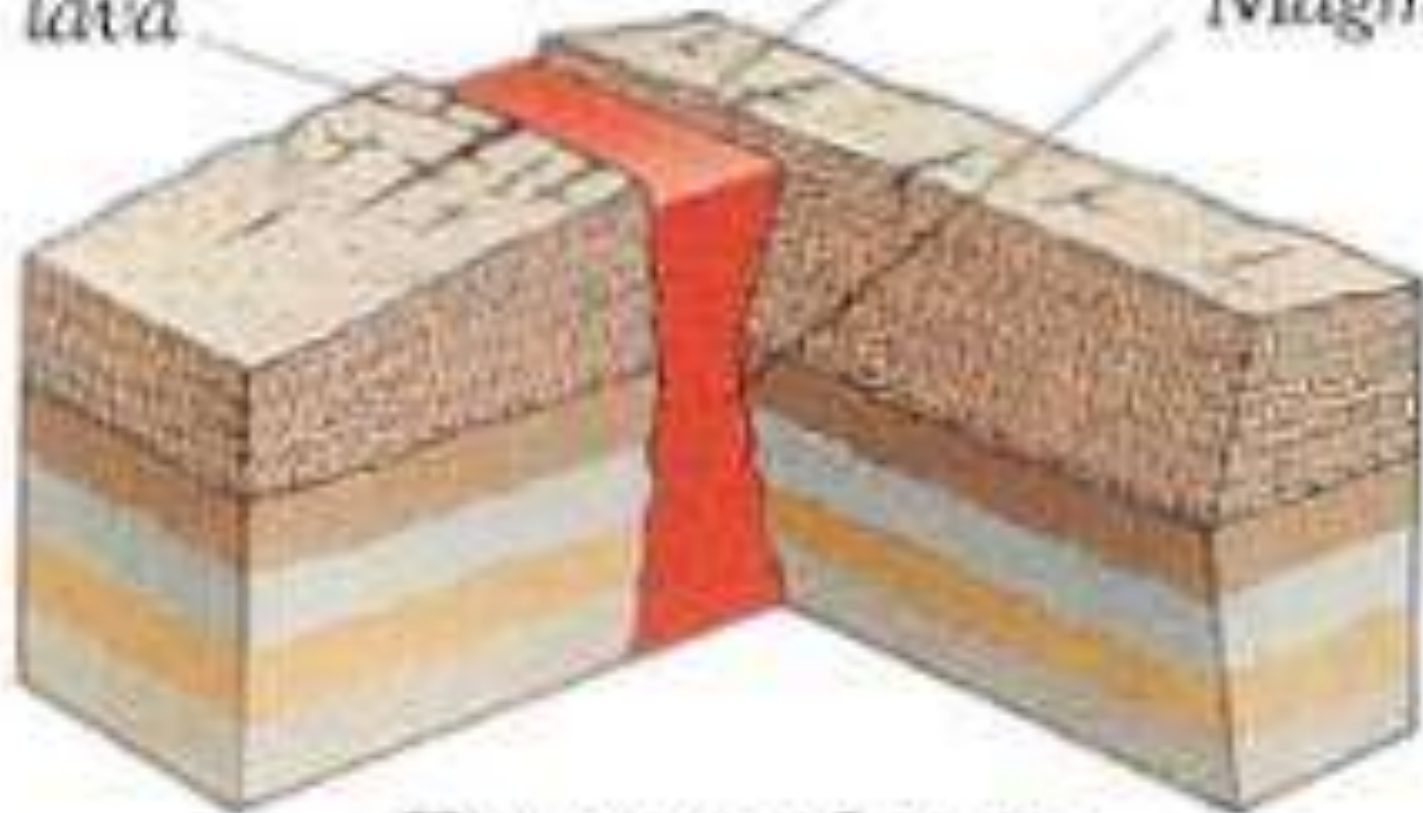
- **Successive fissure eruptions cause lava to flow onto the earth's surface.**
 - **The lava forms thick layers of basalt rock.**
 - **The layers are horizontal and are uniformly resistant to erosion.**
 - **These layers of basalt give rise to basaltic plateaus.**
- 
- A decorative graphic consisting of several parallel white lines of varying lengths, slanted diagonally from the bottom right towards the top right, located in the lower right quadrant of the slide.



Gentle basaltic
slope of
lava

Fissure

Magma



Fissure volcano

COMPLETE THE TABLE BELOW

Column A	Column B
Place where one layer of rock rests on the layer beneath it	Stratified
Landscape found in an arid area	Drakensberg
Landscape made up of gently sloping hills	Strata
Rocks with layers	Bedding plane
Landscape with a thick horizontal layer of basalt at the top	Badlands
	Valley of a thousand hills

Canyon Landscapes

- A **canyon** or **gorge** is a deep ravine between pairs of escarpments or cliffs and is most often carved from the landscape by the erosive activity of a river over geologic timescales.
- Canyon landscapes develop in areas where the rocks are **stratified** and the strata are **horizontal**.
- Canyons are associated with rocks which are **not** uniformly resistant to erosion.

In other words, canyons form from horizontal strata where strata vary in their resistance to erosion.

The Process

- **Tectonic uplift** (rising of a land mass due to crustal forces) results in a large plateau.
- Resistant horizontal layers on the surface prevent the landscape from becoming lower. BUT -----
- **Rivers erode vertically** along joints and cracks and form deep, steep valleys.
- More **resistant strata** – don't erode easily – form vertical **cliffs**.
- Softer layers – erode easily – form the gentle slopes.
 - Canyons often look like giant steps.

Climatic influences



Steeper slopes in arid regions as there is less water to round and erode the slopes. The Fish River canyon is one such example.



Below left, the Blyde River Canyon which experiences humid conditions has a very different appearance.

Karoo Landscapes

- Karoo landscapes develop as a result of the canyon landscapes.
- The Karoo landscape is consists of:
 - Flat-topped mountains or hills of differing widths with steep, concave shaped slopes.
 - The Karoo is a dry area and the lack of rain results in the steeper slopes.
 - The resistant cap rock (hard resistant, layer of rock at the top of the mountain) is usually sandstone with softer shale below. Dolerite sills may also form resistant cap rocks.

Karoo Landscape Formation

- The canyon floor becomes wider and the plateau surface gets narrower. The cap rock remains intact causing the plateau to remain at its original height.
- The **plateau** develops into **mesas** or a series of **ridges**.
- When rain does fall the water erodes away at the softer rock beneath the cap rock.
- Mesas erode to form **buttes**, **pointed buttes** and eventually **conical hills**.

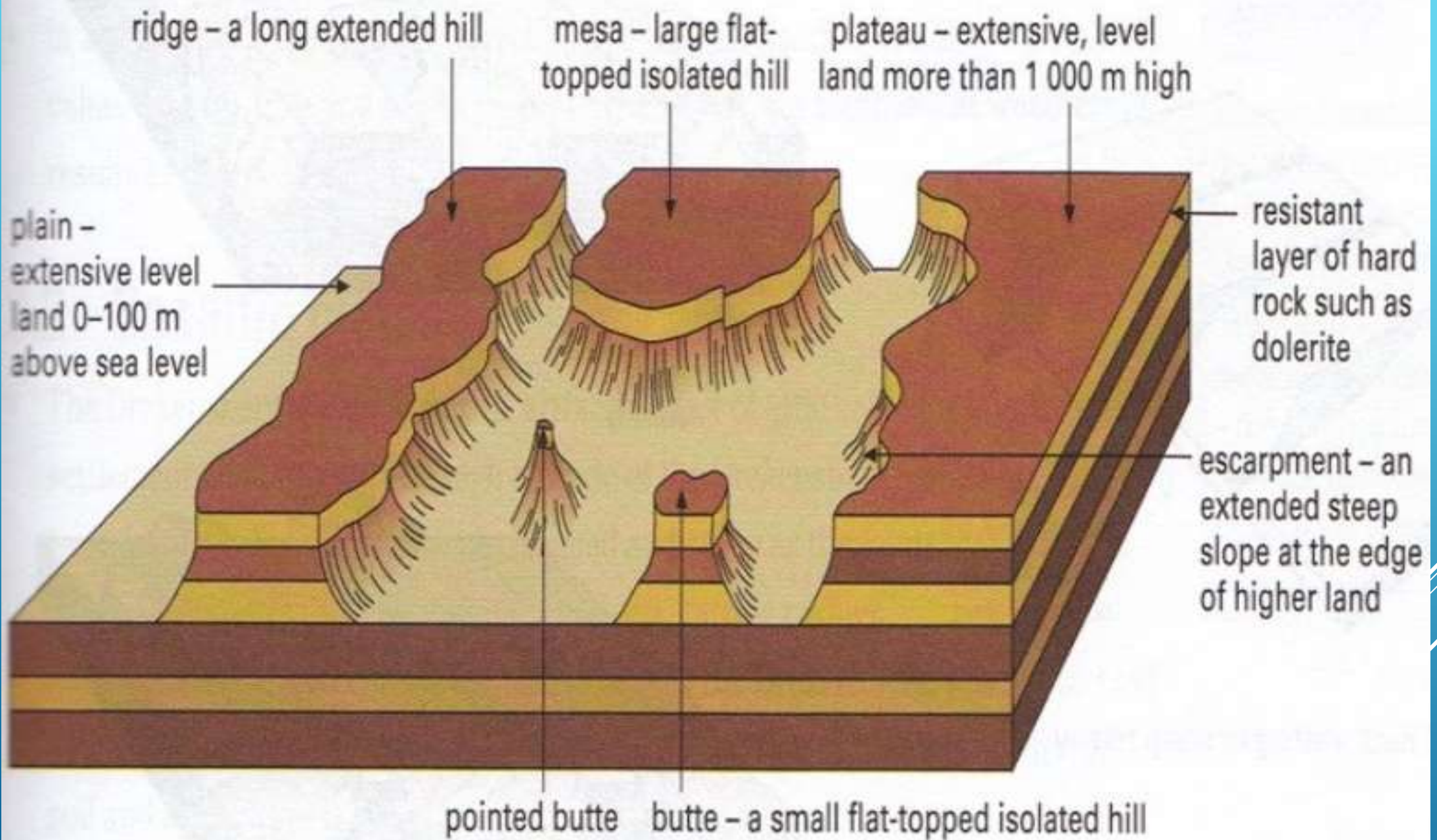
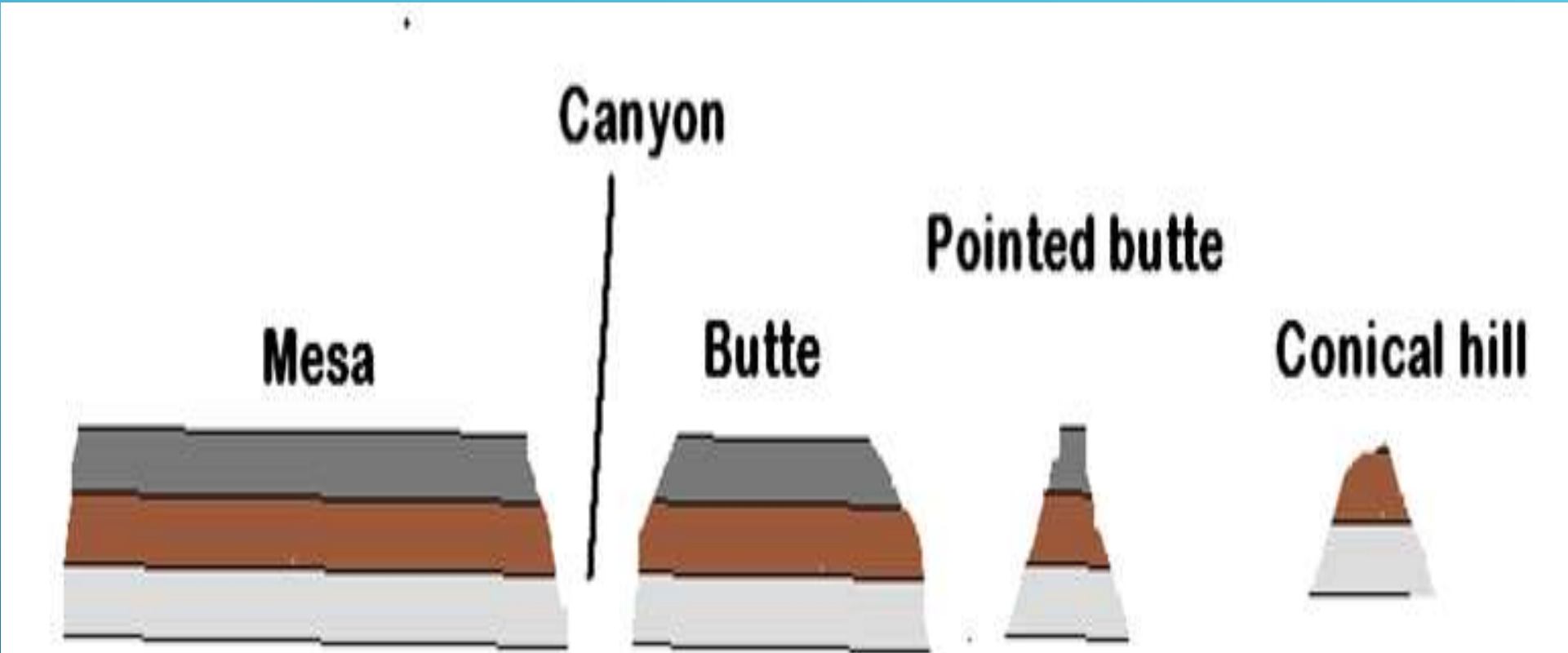


Figure 3.15 Landforms found in a Karoo landscape

Karoo Landscapes

- Mesas – flat-topped table mountains with a greater width than height.
- Buttes – flat topped hills with a greater height than width.
- Pointed buttes – narrow hills with a sharp peak at the top.
- Conical hills – small pointed hills.



Mesa

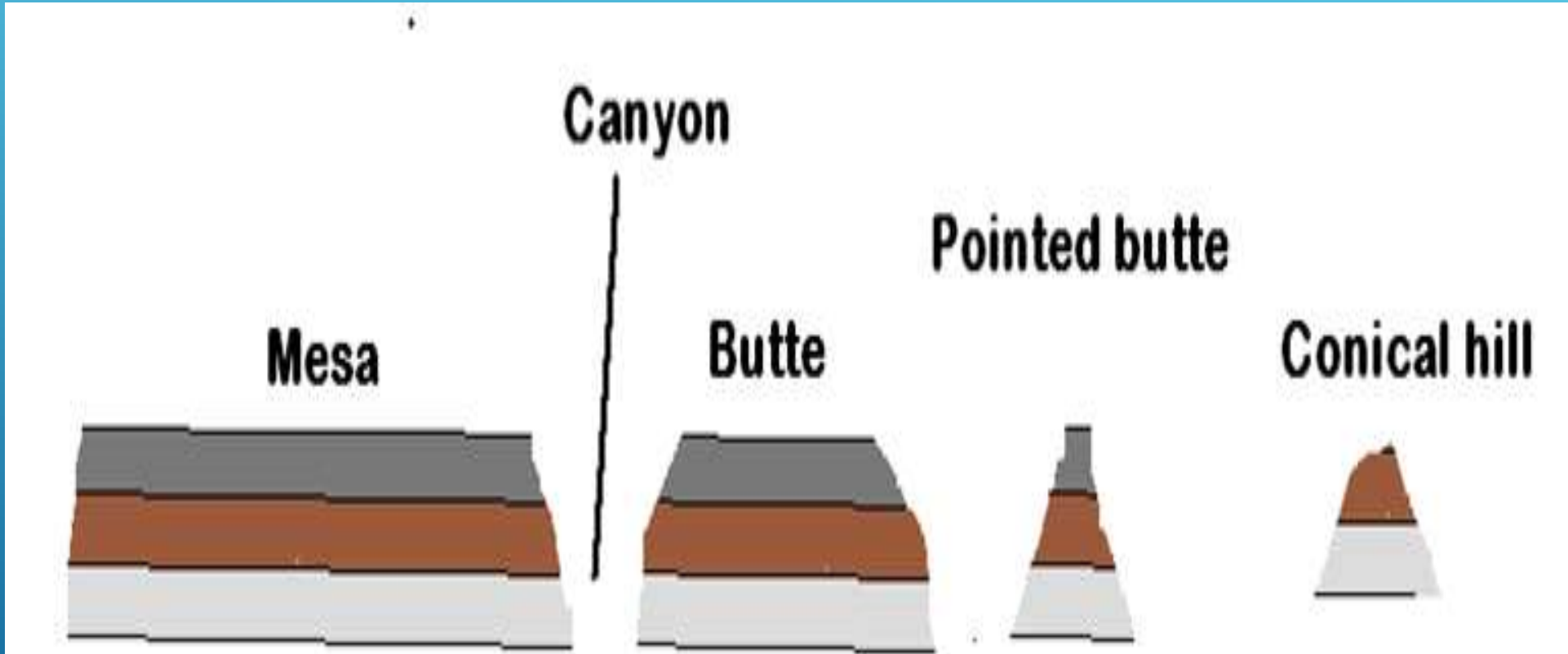
Canyon

Butte

Pointed butte

Conical hill

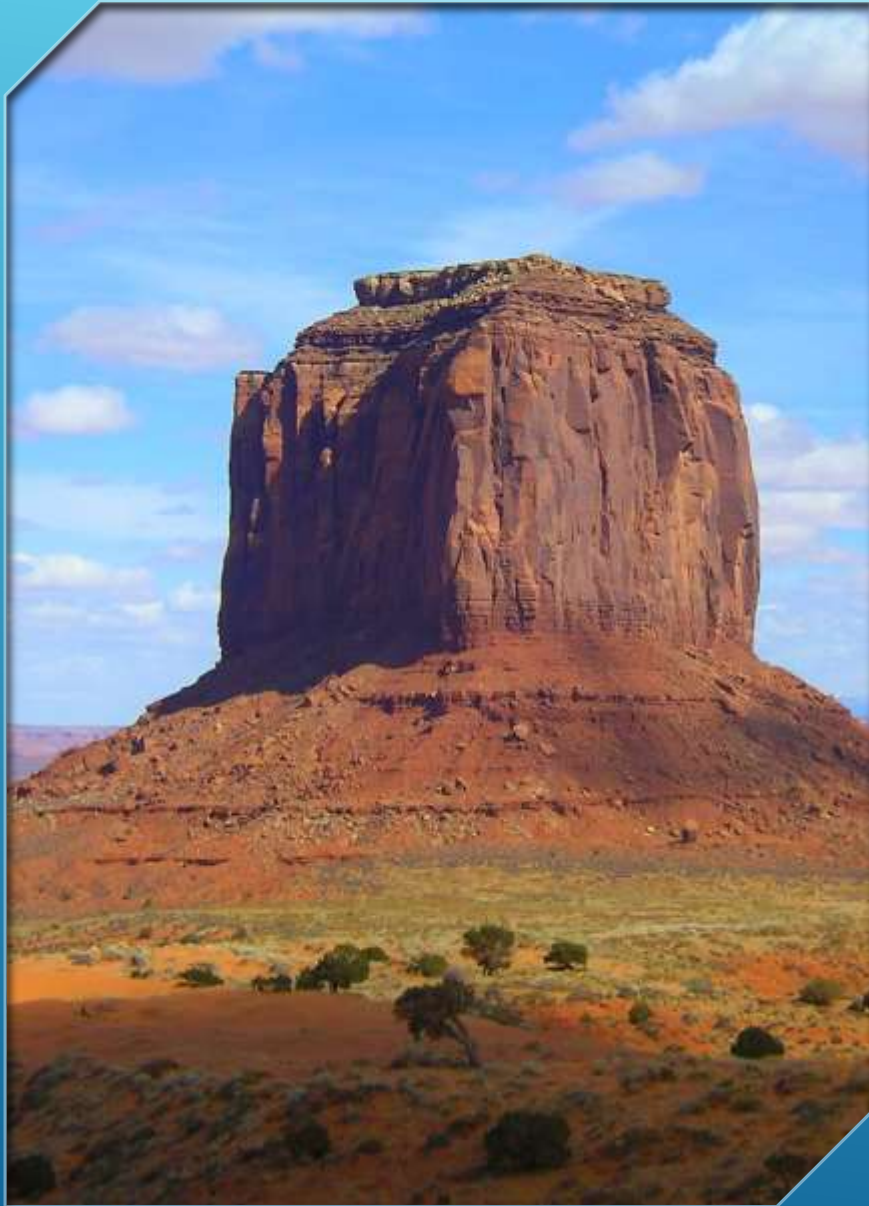
HOW FEATURES OF A KAROO LANDSCAPE FORM:





1. MESA'S

- Mesa means table, they formed by weathering & erosion of horizontally layered rock that have been uplifted by tectonic activity
- When a more resistant rock strata overlies a less resistant strata, erosion cuts back the less resistant rock, the more resistant rock cant support itself and falls
- This creates steep cliffs, at the more resistant cap, and a pediplain lower down.



BUTTES

- Butte is French for “small hill”
- Further erosion of the mesa occurs creating buttes



CONICAL HILLS

- Conical hills are formed as a result of further erosion of a butte
- The resistant rock cap is fully removed by erosion, leaving only the softer layers underneath.

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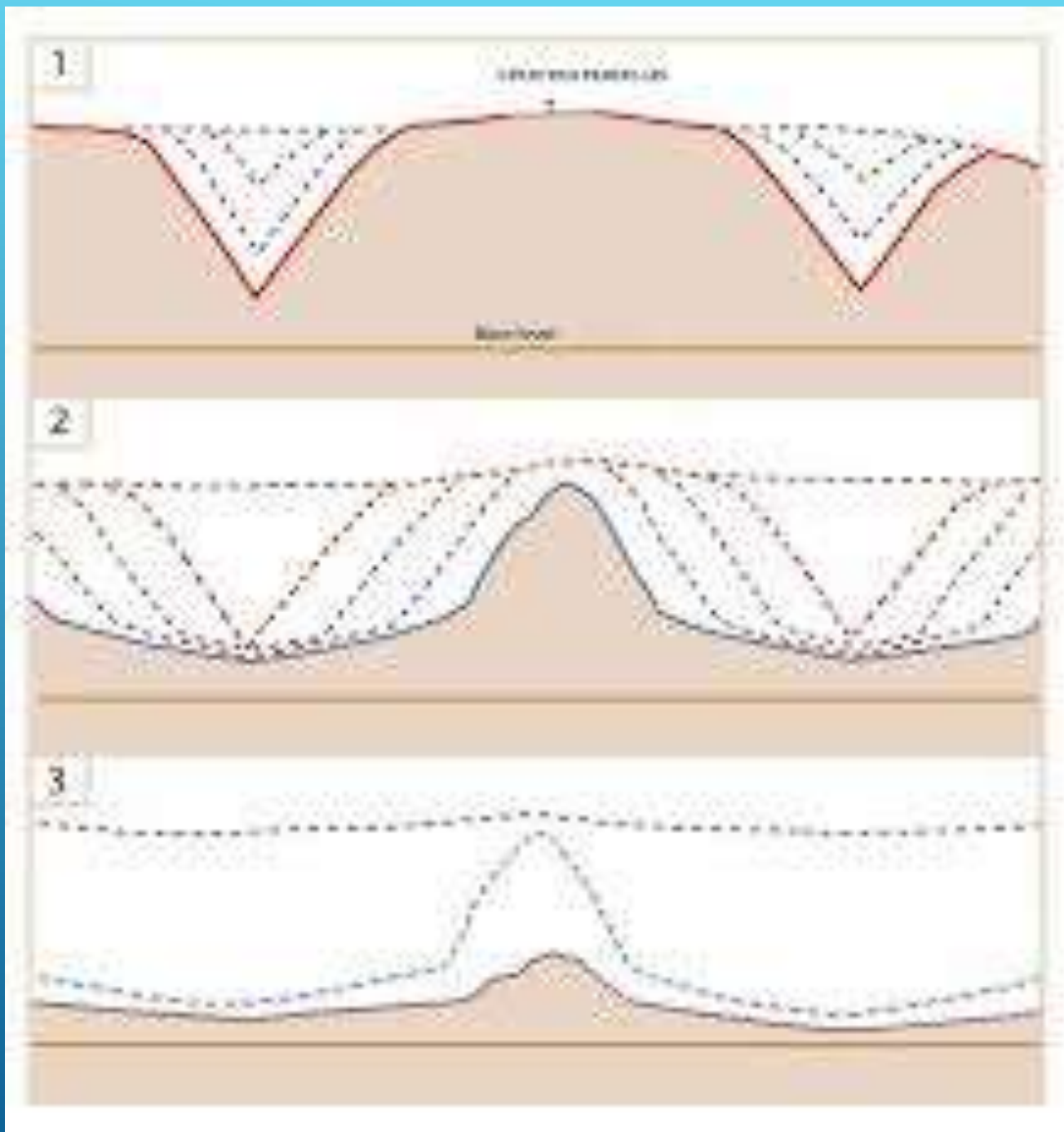


SCARP RETREAT / BACK WASTING

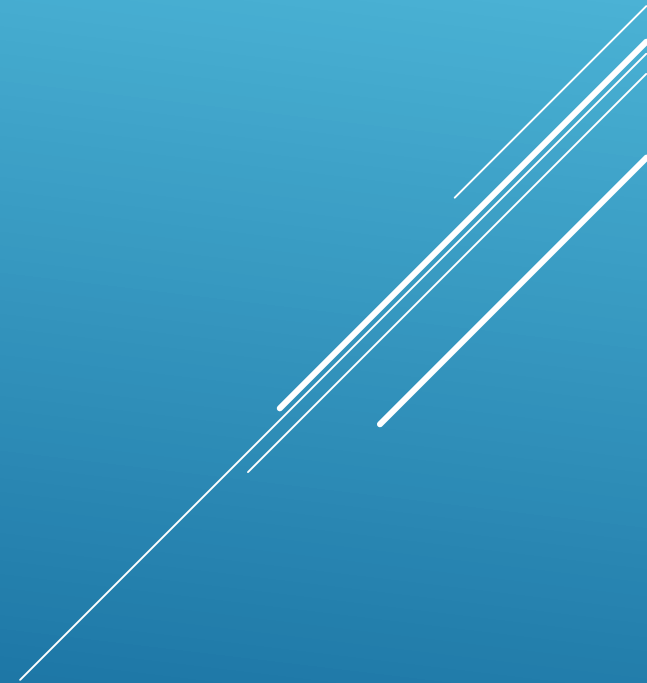


WHAT IS SCARP RETREAT

- **Scarp retreat is how slopes erode and change over time**
- **With scarp retreat, slopes remain the same angle through the erosion stages.**
- Erosion starts as uplift occurs, slopes erode uniformly when there is uniformly tectonic uplift
- Erosion and deposition take place on landforms such as mesa's or buttes, the land forms get narrower but slopes remain the same angle.
- For this development to occur the erosion at the base of the slope must at the same rate as the removal of material from the scarp slope.
- Only the pediment will become larger over time creating a large flat valley floor.
- Features become narrower, but will only become shorter when the cap rock is removed
- This is the process of scarp retreat or back wasting

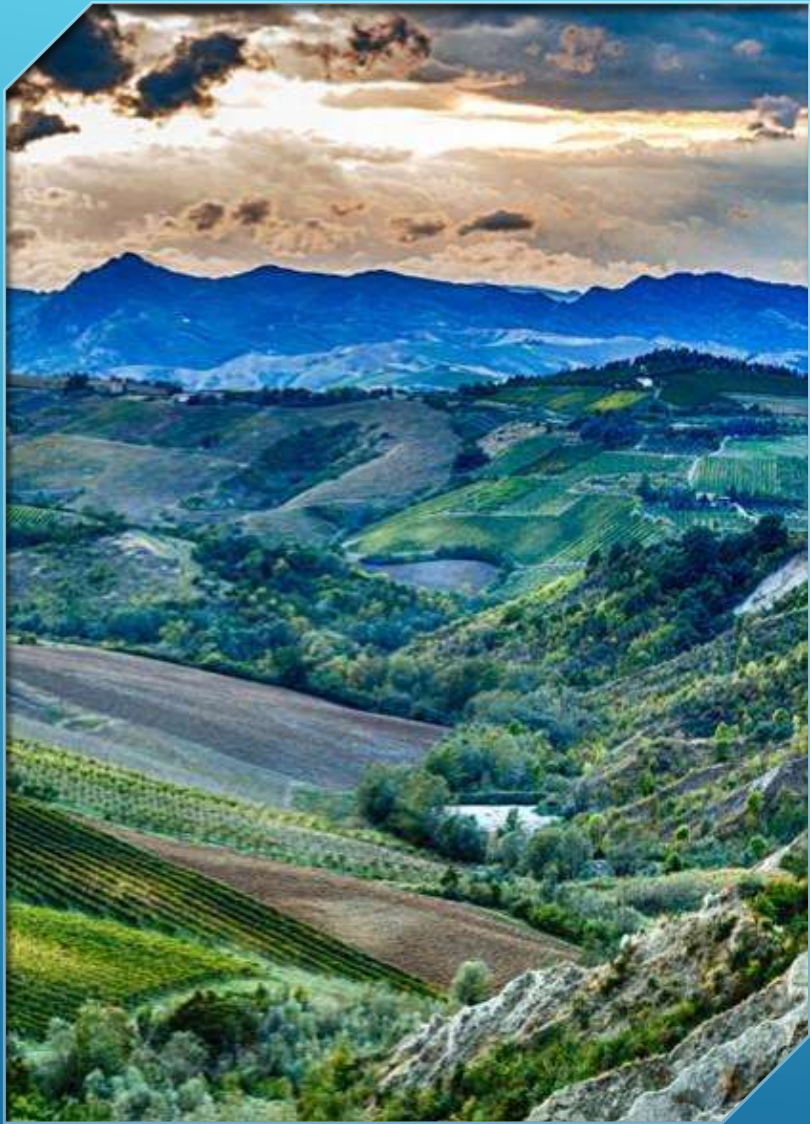


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HOW PEOPLE USE THESE LANDSCAPES





1. *HILLY LANDSCAPES*

- Hilly, round landscapes are fertile agricultural areas with high rainfall and warmer weather.
- Although the soil may be thin the use of contour ploughing allows people to farm.



ock photo

2. BASALTIC PLATEAUS

- Weathered lava plateaus produce very fertile soil, as well as sufficient water
- This allows for humans to use this land for agriculture
- The Deccan plateau in India is used for large scale commercial cotton farming



3. CANYON LANDSCAPES

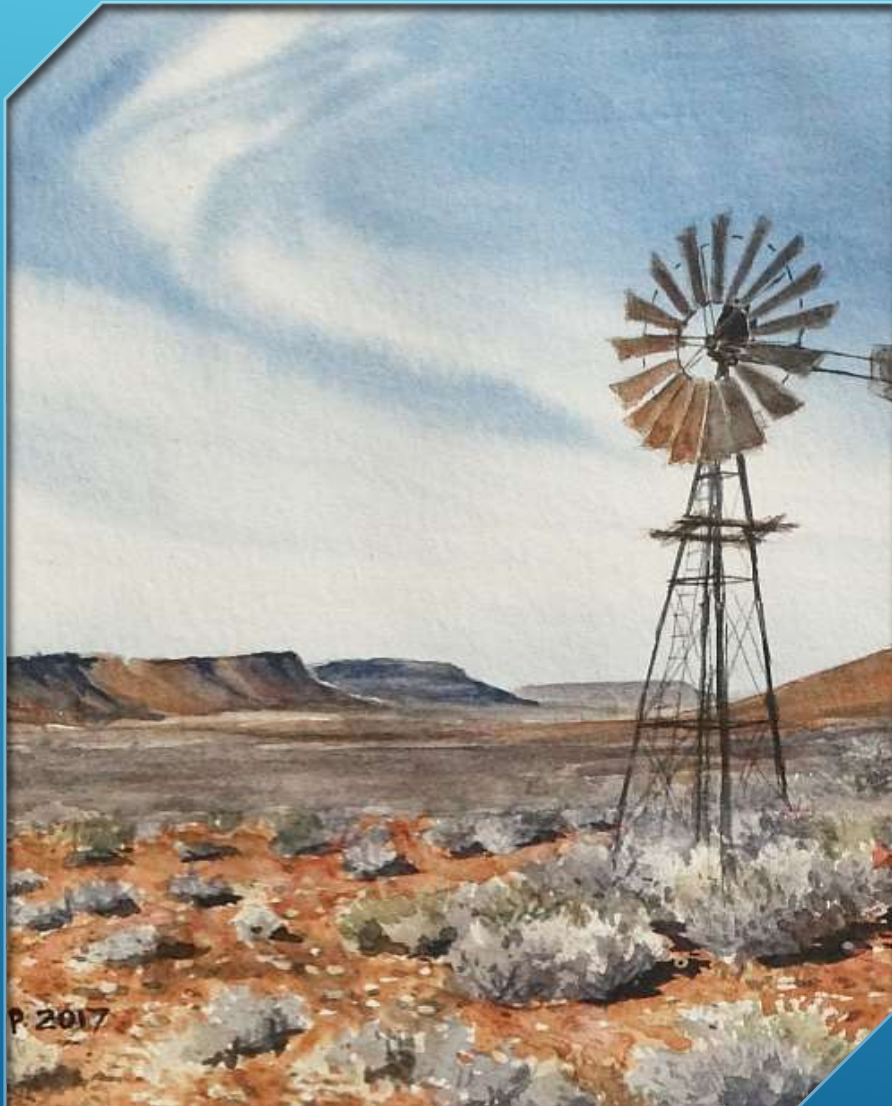
- Canyon landscapes offer historical relevance for early human settlement
- However act as barriers to infrastructure and transport routes
- Too dry and rivers too deep for farming
- **Attract tourists (Grand canyon)**
- Badlands offer no real value to humans as the slopes are too steep and erosion lowers the value of the land further.

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4. KAROO LANDSCAPES

- Due to the arid areas Karoo landscapes are found in, they offer no significance to humans.
- Erosion is high, and soil is thin and infertile



UNIT 4: TOPOGRAPHY ASSOCIATED WITH INCLINED/TILTED ROCK STRATA

The image features a solid blue background with a gradient from light blue at the top to a darker blue at the bottom. In the bottom right corner, there are several white, parallel, diagonal lines that appear to be part of a larger graphic or design element.

KEY TERMS:

Homoclinal ridge – ridge formed from inclined strata

Scarp slope – steep slope of a homoclinal ridge

Dip slope – less steep slope of a homoclinal ridge

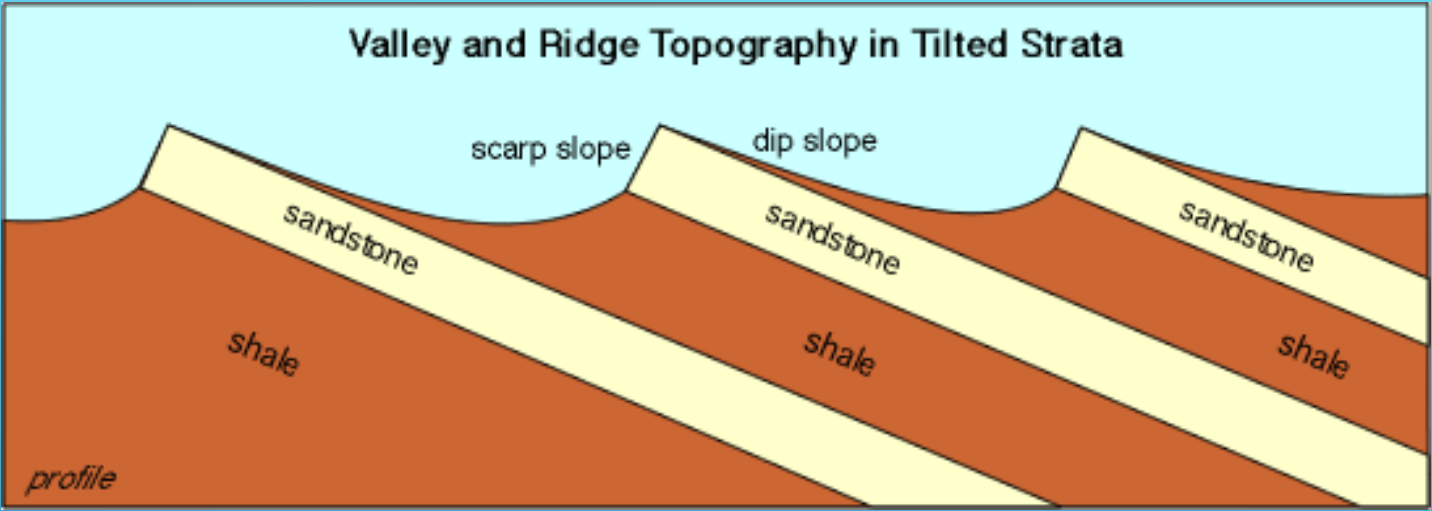
Mass wasting – movement of eroded material down a slope due to gravity

Undercutting – erosion of rock at the base of a slope with subsequent collapse of the overhang

Homoclinal shifting – movement of a homoclinal ridge towards the dip slope

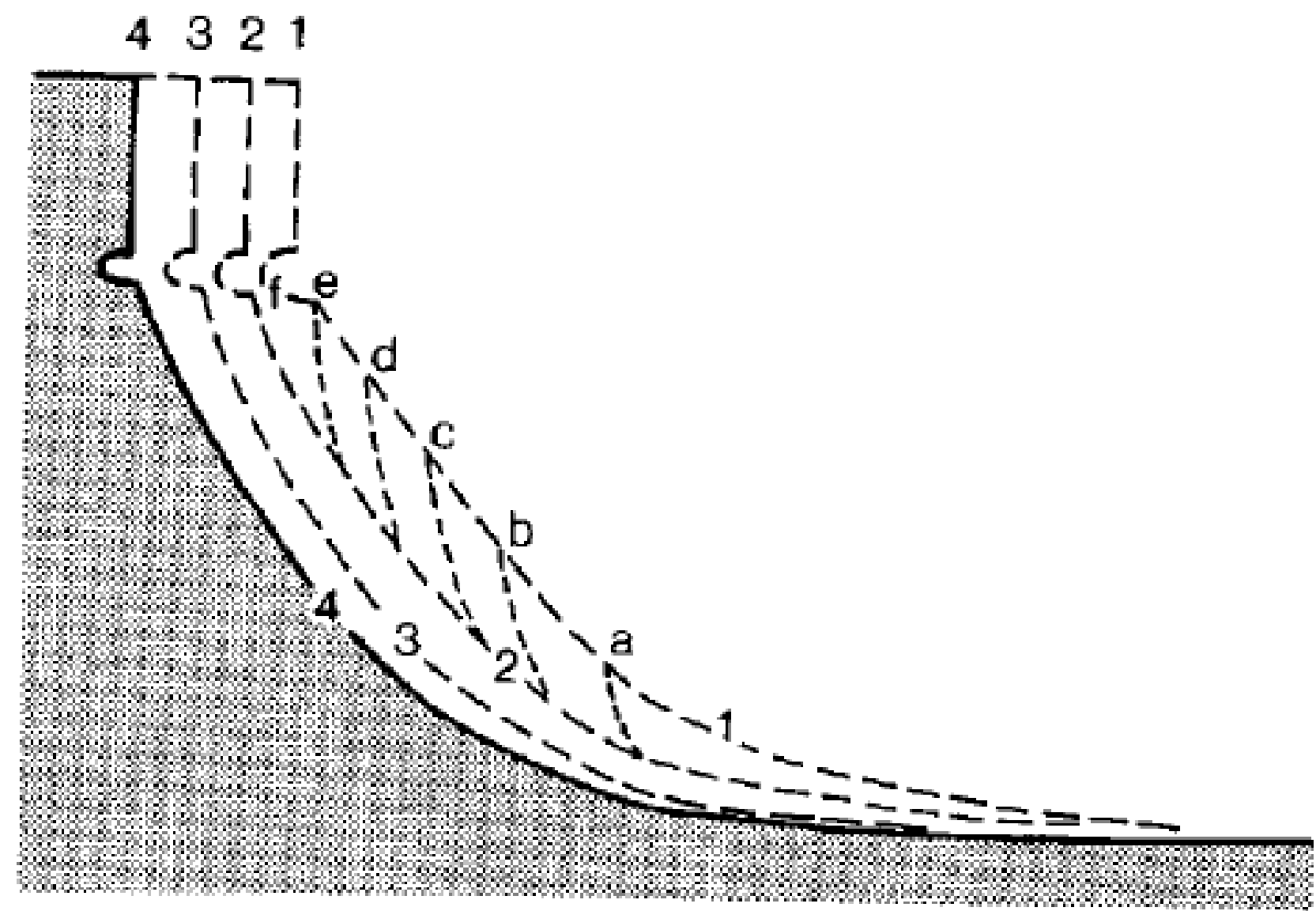
CHARACTERISTICS & PROCESSES ASSOCIATED WITH THE DEVELOPMENT OF HOMOCLINAL LANDSCAPES

- Homoclinal ridges are asymmetrical ridges which have a steeper slope on one side and a gentler slope on the other.
- These form from alternating sedimentary rock strata of varying resistances that have been uplifted and tilted by warping, folding and faulting.
- Homoclinal landscapes refer to a landscape formed of inclined strata that are tilted by the same degree of dip in the same direction.



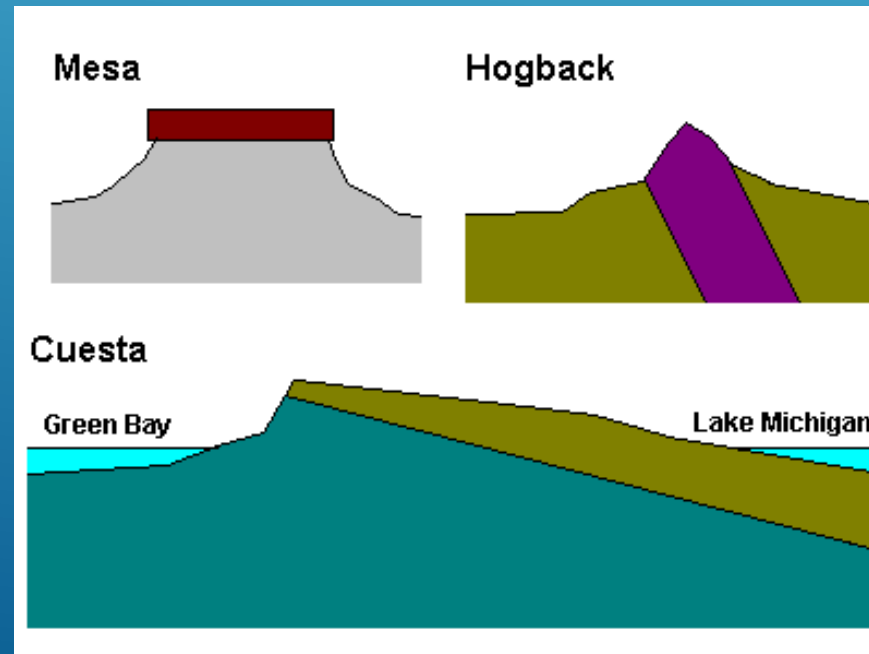
1. DIP AND SCARP SLOPES

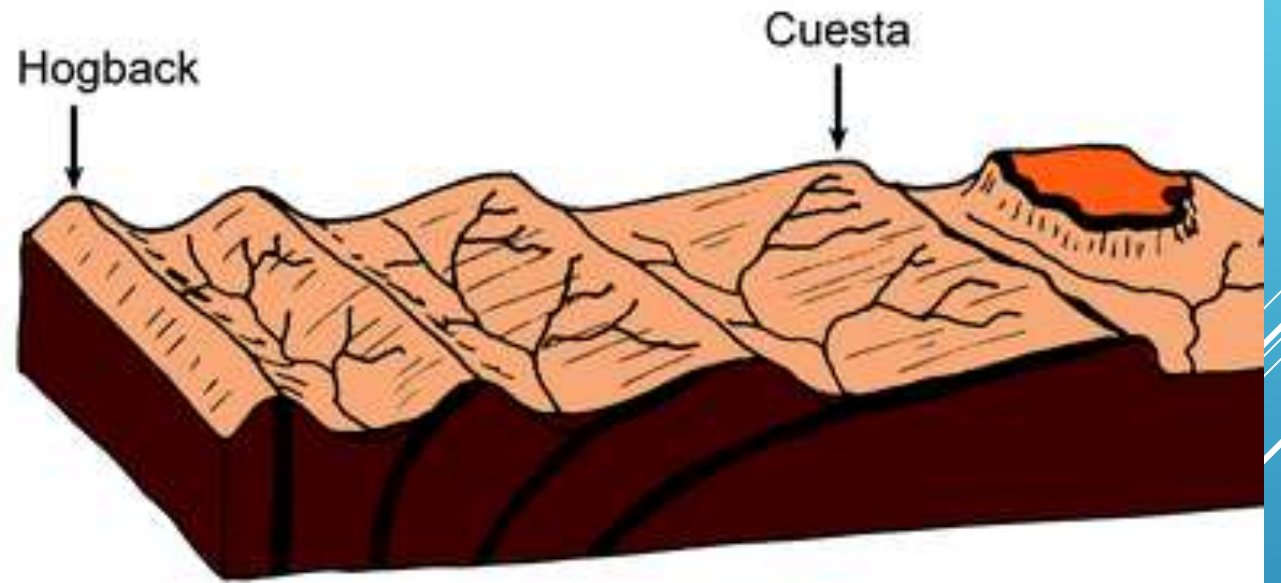
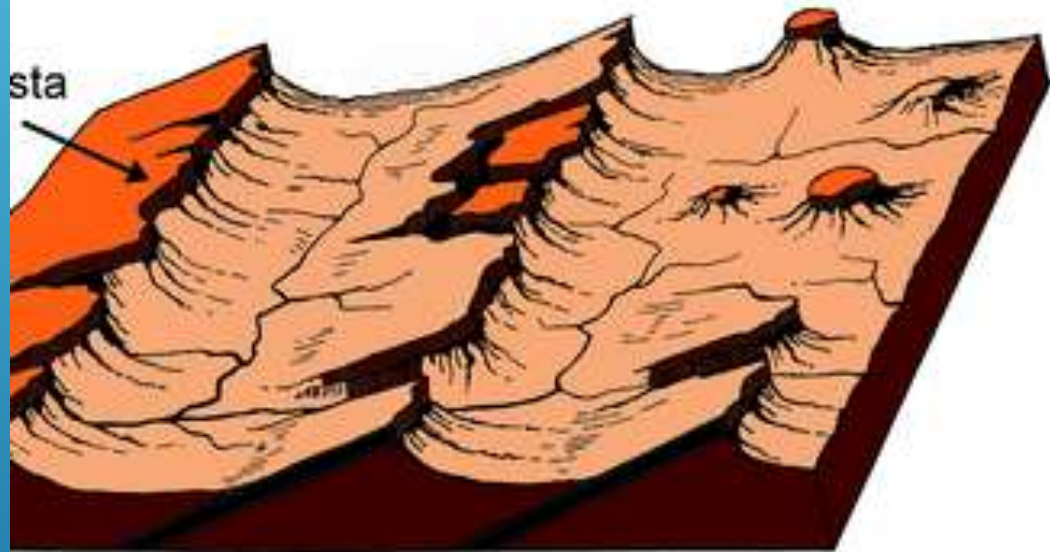
- **Surface erosion exposes the inclined strata.**
- **This results in ridges having a scarp slope and a dip slope.**
- **Erosion is less on the dip slope as it has a more resistant rock than the scarp slope**
- **The scarp slope is eroded through sheet wash and mass wasting**
- **Scarp recession occurs as undercutting and collapse cause the scarp slope to erode in the direction of the dip slope. (homoclinal shifting)**



CUESTAS AND HOGSBACKS

- Depending on the angle of the resistant strata, we differentiate between a cuesta and a hogback
1. Cuesta the dipping strata lie at an angle of 10 – 25 degrees
 2. Hogback the dipping strata lie at an angle of more than 45 degrees





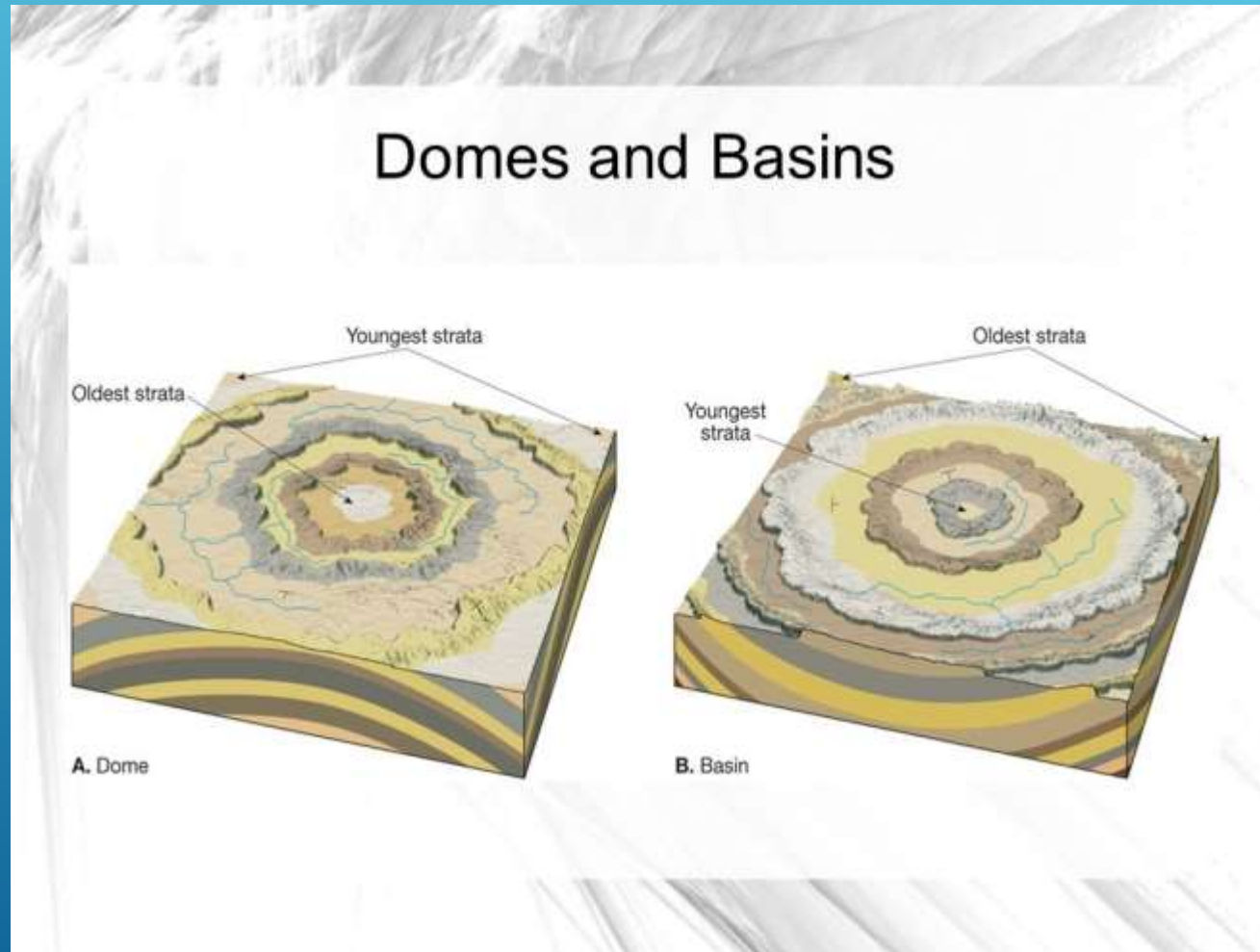
Hogback and Cuesta



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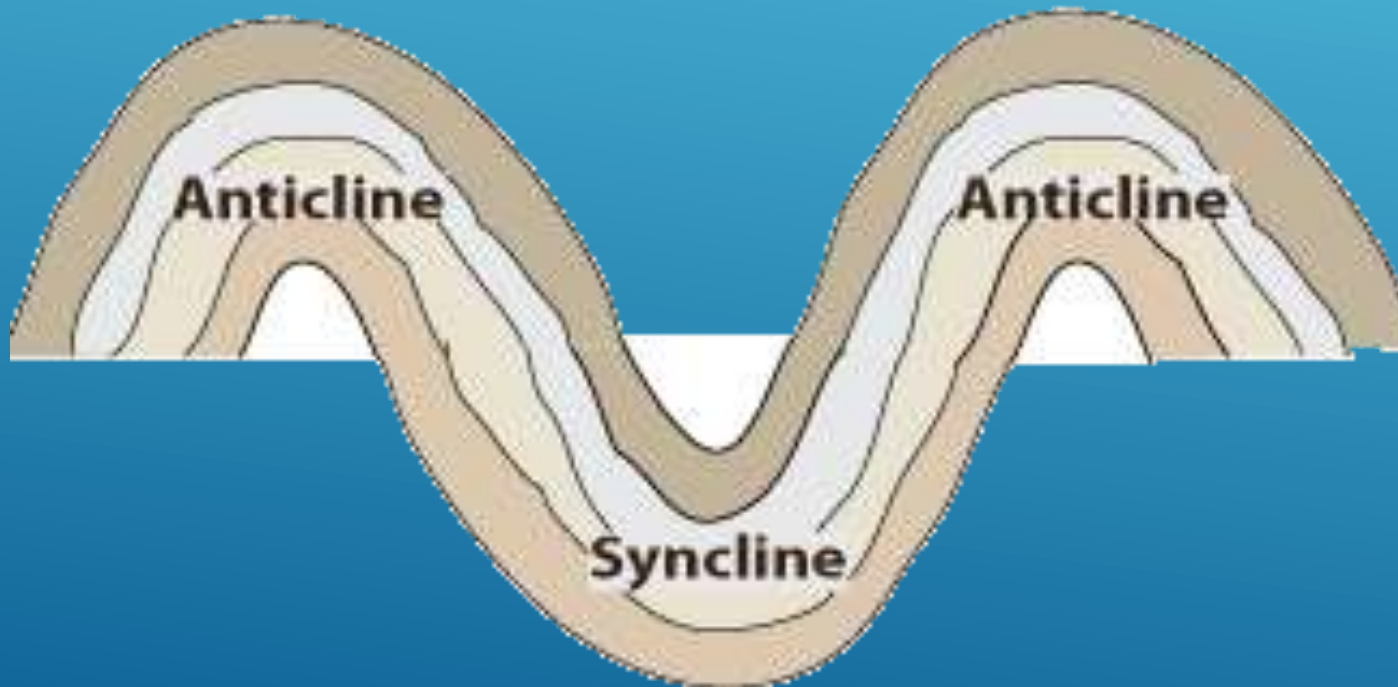


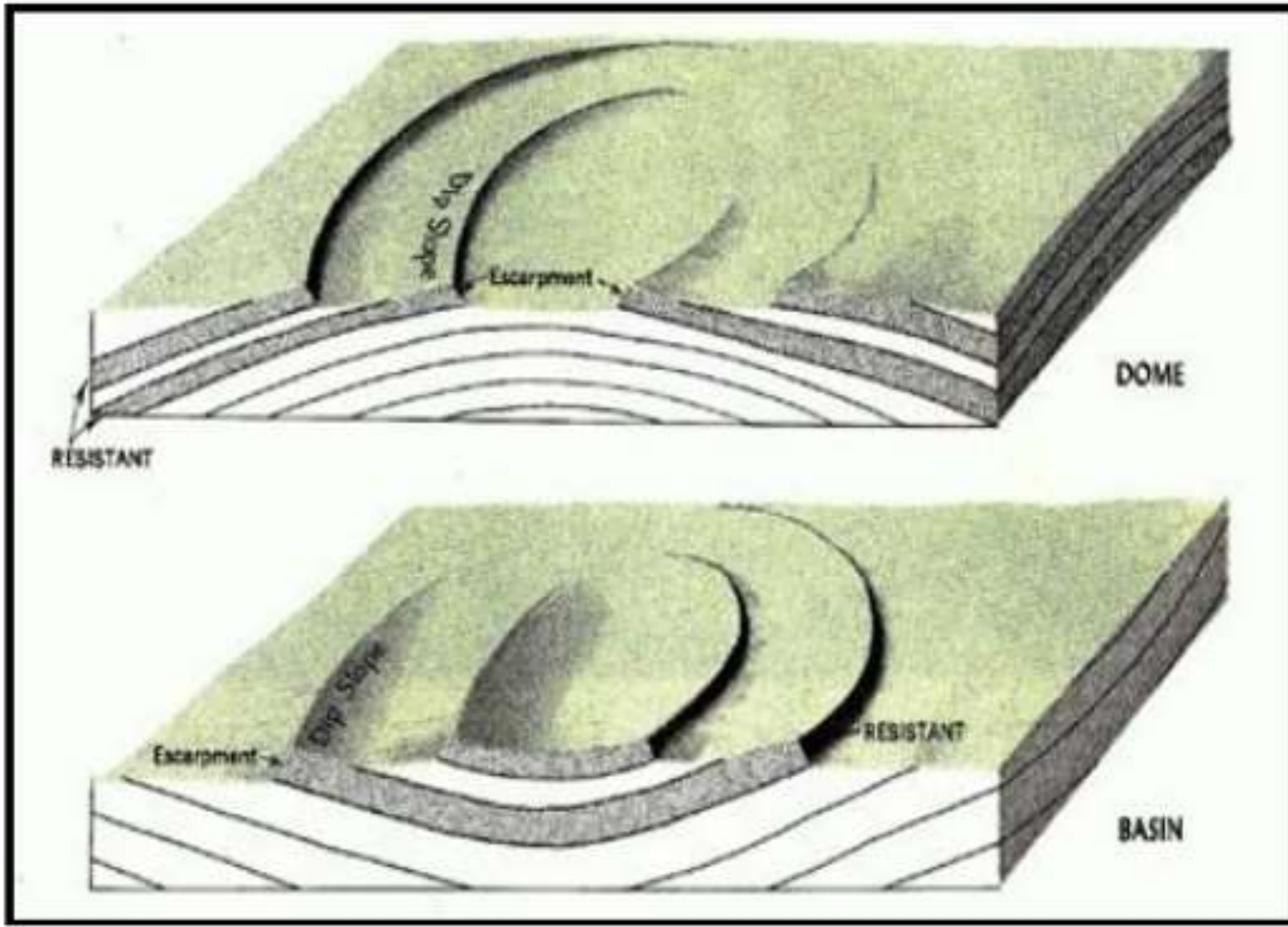
CUESTA BASINS & CUESTA DOMES

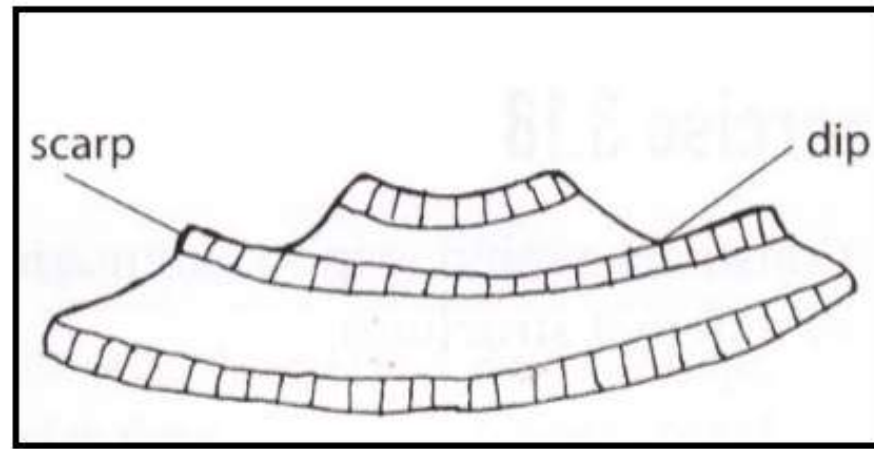


FORMATION OF CUESTA BASINS & DOMES

- As a result of folding, strata are raised into a dome shape or bend downwards into a basin shape.
- Erosion of overlying material leads to a circular shape called cuesta domes or cuesta basins





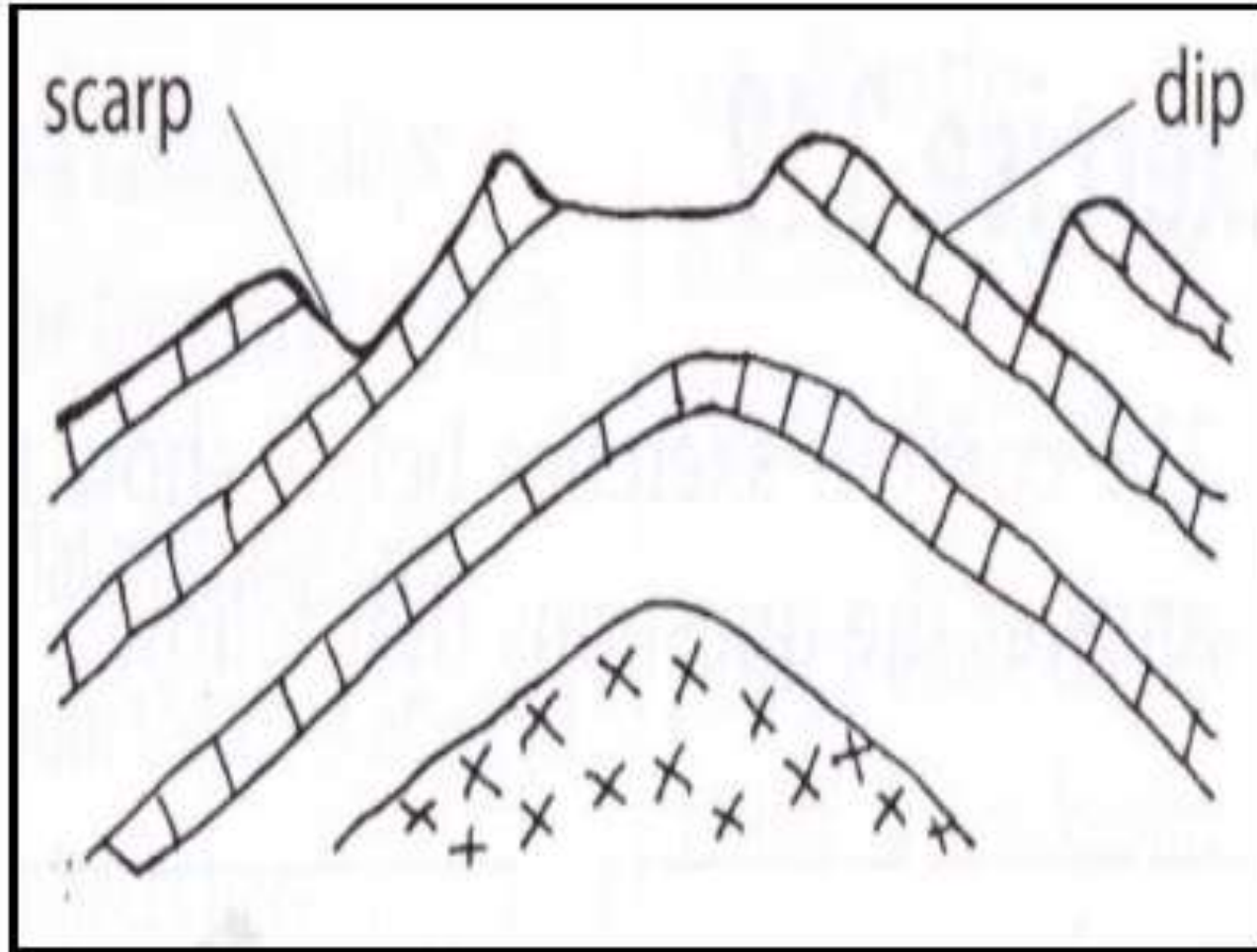


Cuesta Basins


- Cuesta basins are formed as a result of volcanic intrusions of a lopolith.
- The scarp slope faces downward, and the dip slope is directed inward.
- These hold artesian wells and can form oil traps.

Cuesta Dome

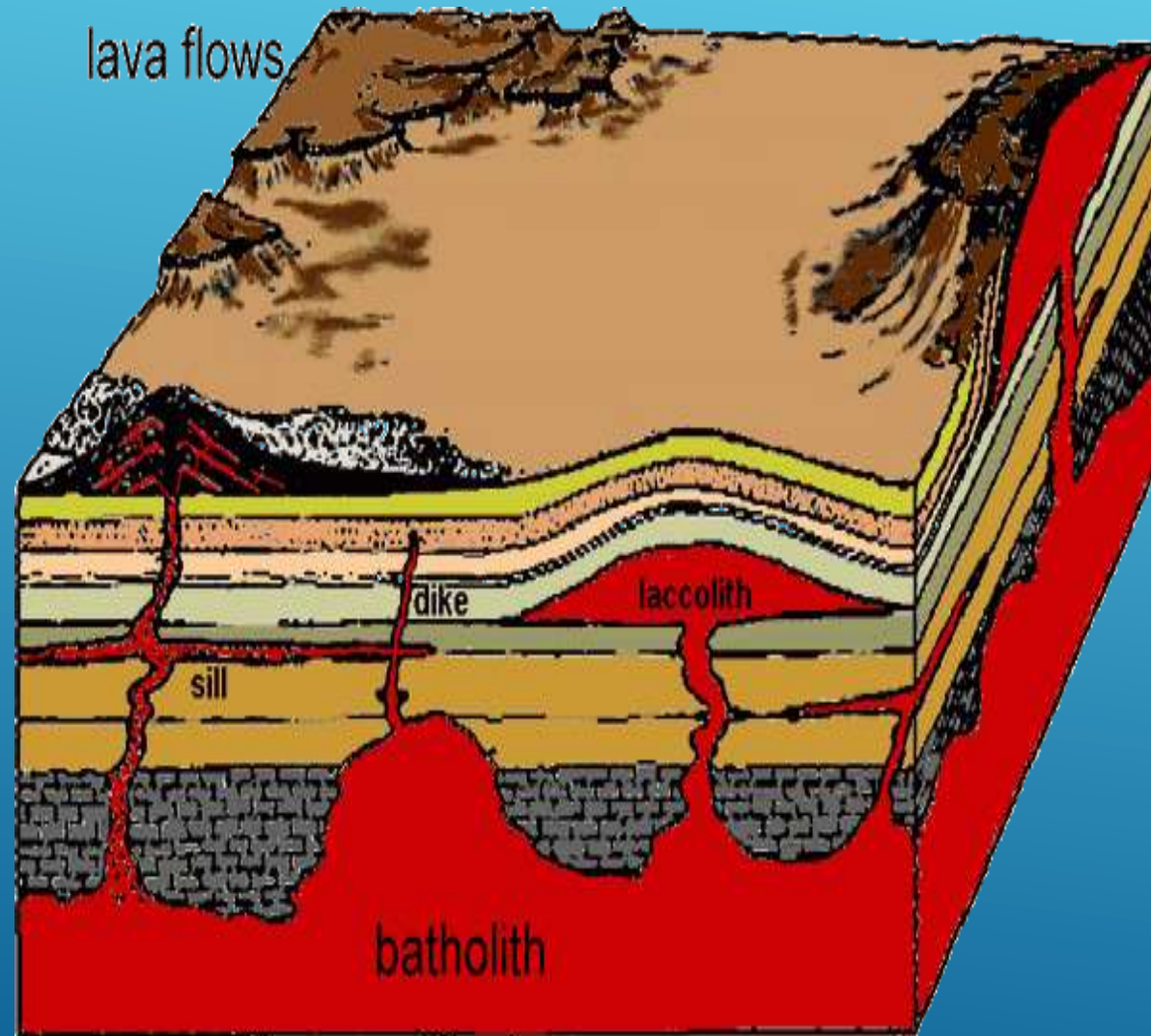
- Cuesta domes are formed as a result of volcanic intrusions of a batholith and lacolith.
- The scarp slope faces inward, and dip slopes faces outward.




UTILISATION OF LANDSCAPE ASSOCIATED WITH INCLINED STRATA

- *The dip slope of cuesta is rocky with thin soil, this is used for forestry*
 - *The scarp of a cuesta slope is too steep to be used by people*
 - *Homoclinal ridges are areas used to build dam walls*
 - *Cuesta domes may contain oil or gas*
 - *Cuesta basins may hold (artesian wells) if a layer of permeable rock lies between 2 layers of impermeable rock.*
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TOPOGRAPHY ASSOCIATED WITH MASSIVE IGNEOUS ROCKS

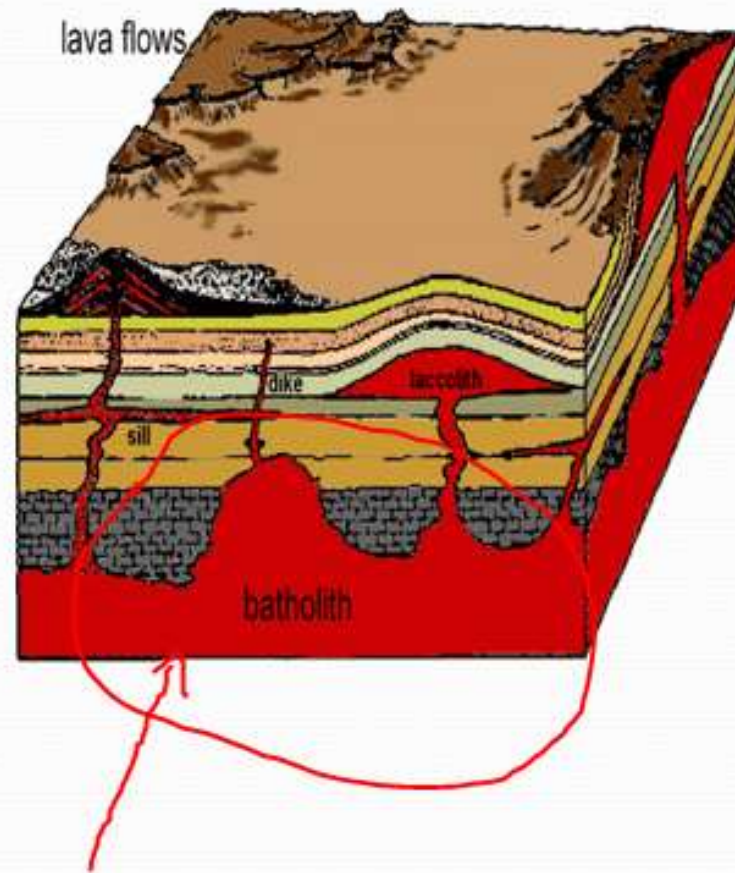


INTRUSIVE IGNEOUS ACTIVITY & FEATURES

- **The Earth's mantle is made of magma (molten rock), magma is less dense than rock and works its way through cracks and joints to the earth's crust.**
 - **When magma cools it forms igneous intrusions.**
 - **We classify these igneous intrusions according to their shape, size and depth.**
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1. Batholiths

- Batholiths are the largest & deepest igneous intrusions
- They can cover 1000's of km & are associated with continental movements
- Magma cools slowly to form rocks with large crystals, granite is the most common rock associated with batholiths.



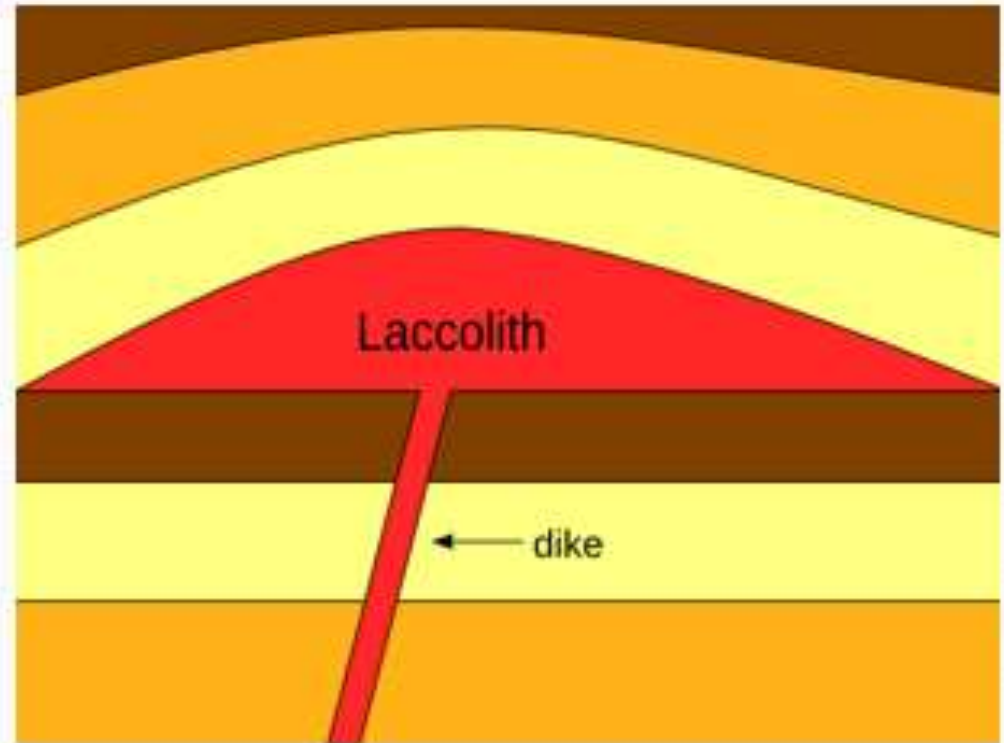
2. Monolith

- Monoliths are very large intrusions.
- When exposed on the earth's surface they form a huge area of domed rock.
- Monoliths are batholiths that have been exposed.



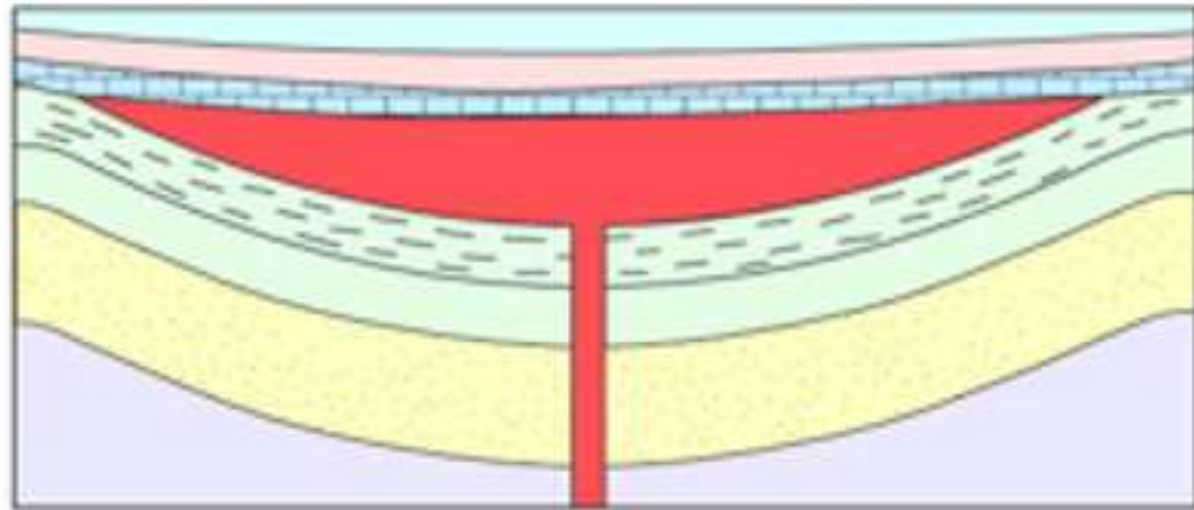
3. Laccoliths

- Laccoliths are dome-shaped intrusions.
- They form when magma is forced between layers of sedimentary rock & pushes up the layers of rock above it.
- Laccoliths can cause mountains to be pushed up.



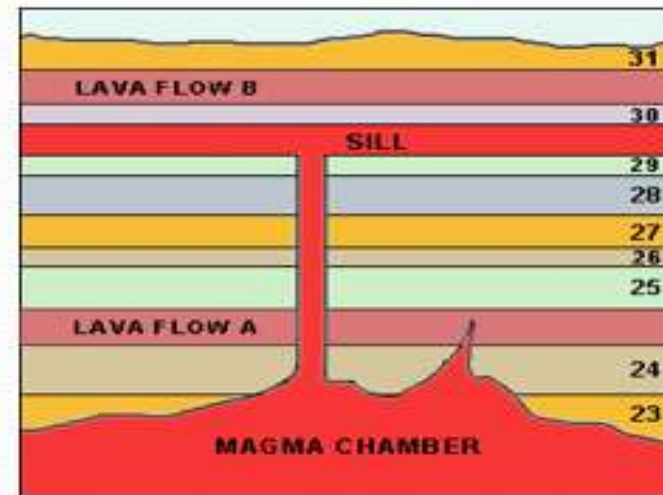
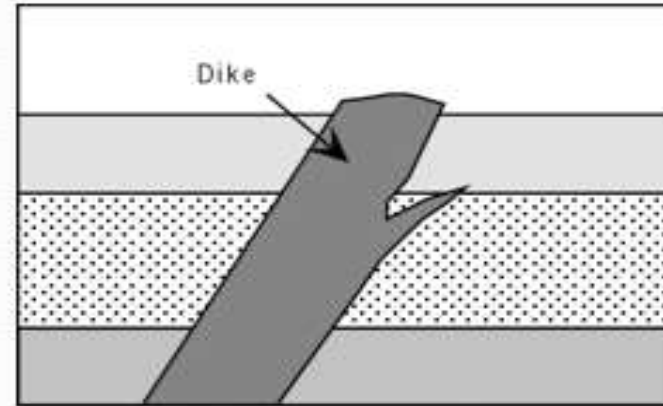
4. Lopolith

- Similar to a laccolith, but the weight from the overlying strata causes the lopolith to sink into a saucer shaped structure



5. Dykes & sills

- Dykes are caused by magma forcing its way vertically through layers of rock.
 - They are usually only a few meters across.
 - Dolerite is a common rock seen in dykes.
-
- Sills are caused by magma forcing its way horizontally through layers of strata.
 - Sills can stretch many kilometers.






Sill

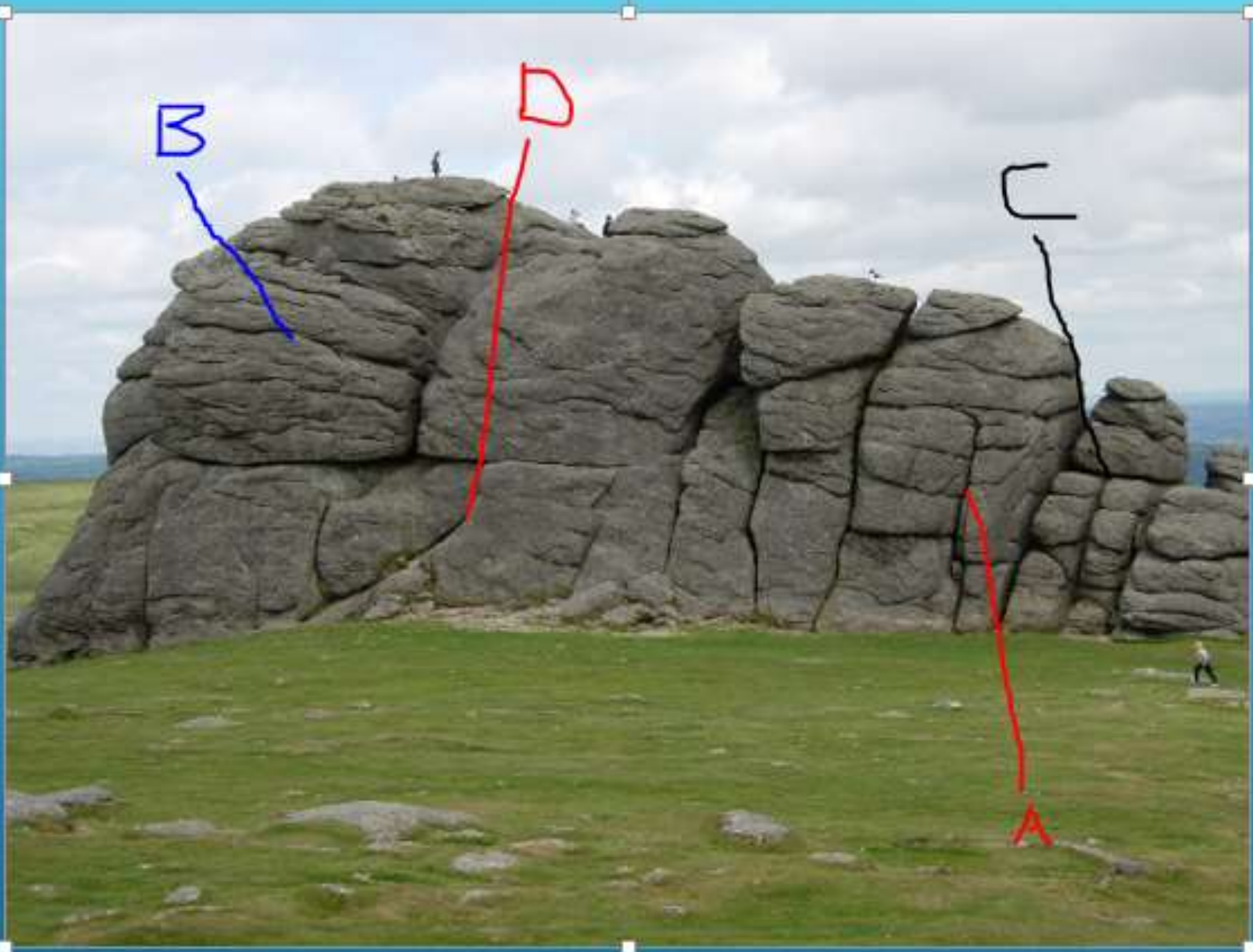


Dyke



GRANITE BATHOLITHS

- Massive igneous rocks don't have bedding planes but they do have joints and cracks
 - Joints form when magma cools, it contracts and solidifies to form granite, these contractual joints cross one another at right angles
 - Pressure from overlying material compresses the granite and forms pressure-release or off-loading joints.
- 



GRANITE DOMES AND TORS



Clear
IAS
www.clearias.com

exfoliation dome

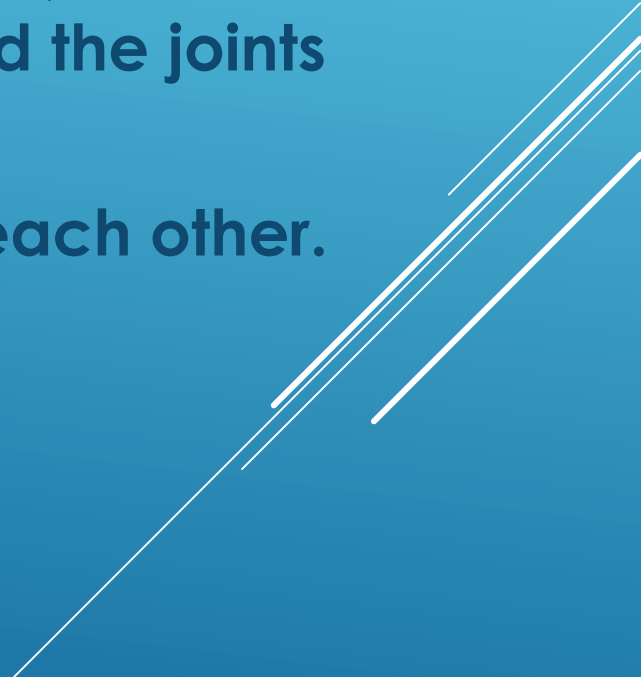


1. GRANITE DOMES

- Granite domes are exposed batholiths (monoliths)
- The dome is made visible by erosion of the overlying material, or uplift that takes place below the earth's surface
- As the dome is exposed, it undergoes pressure release due to the weight of the overlying material being removed
- As the pressure is released the granite expands, causing dilation joints to form along the surface
- Further erosion and weathering along these joints cause exfoliation type weathering and slabs of granite slip off the dome



2. TORS

- Tors are composed of granite, dolerite or metamorphic rocks that form when erosion widens the rocks joints
 - Before being exposed water seeped into the ground and chemically weathered the parent rock along its joints and bedding plains.
 - Following uplift or the removal of material due to erosion, the rocks are weathered and eroded at an accelerated rate, and the joints are enlarged
 - This structure appears as boulders loosely stacked on each other.
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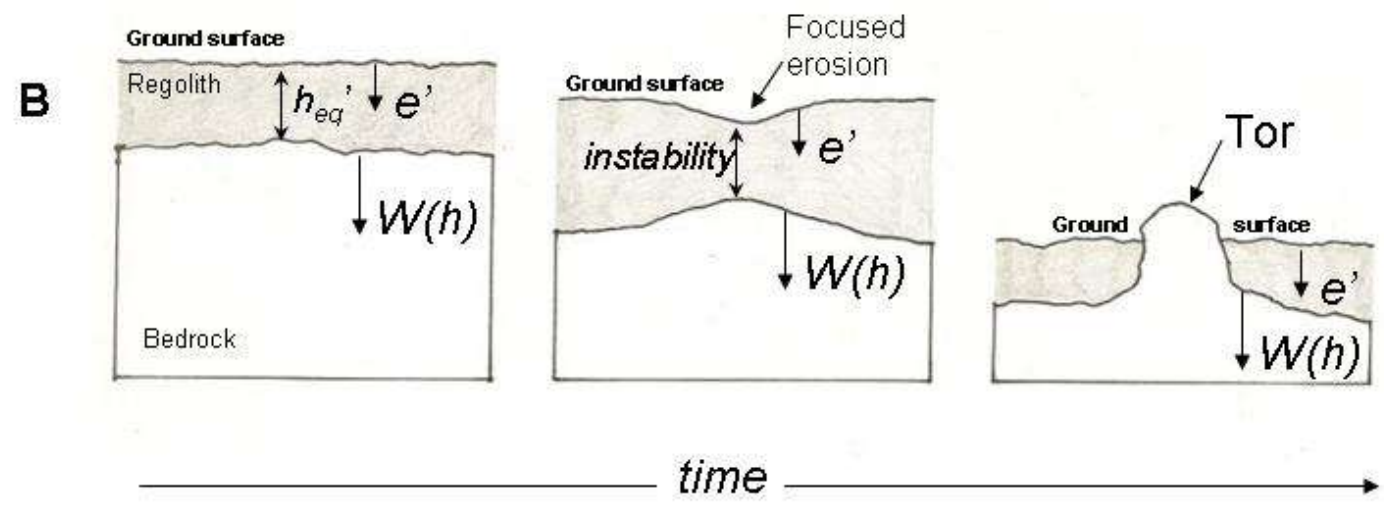
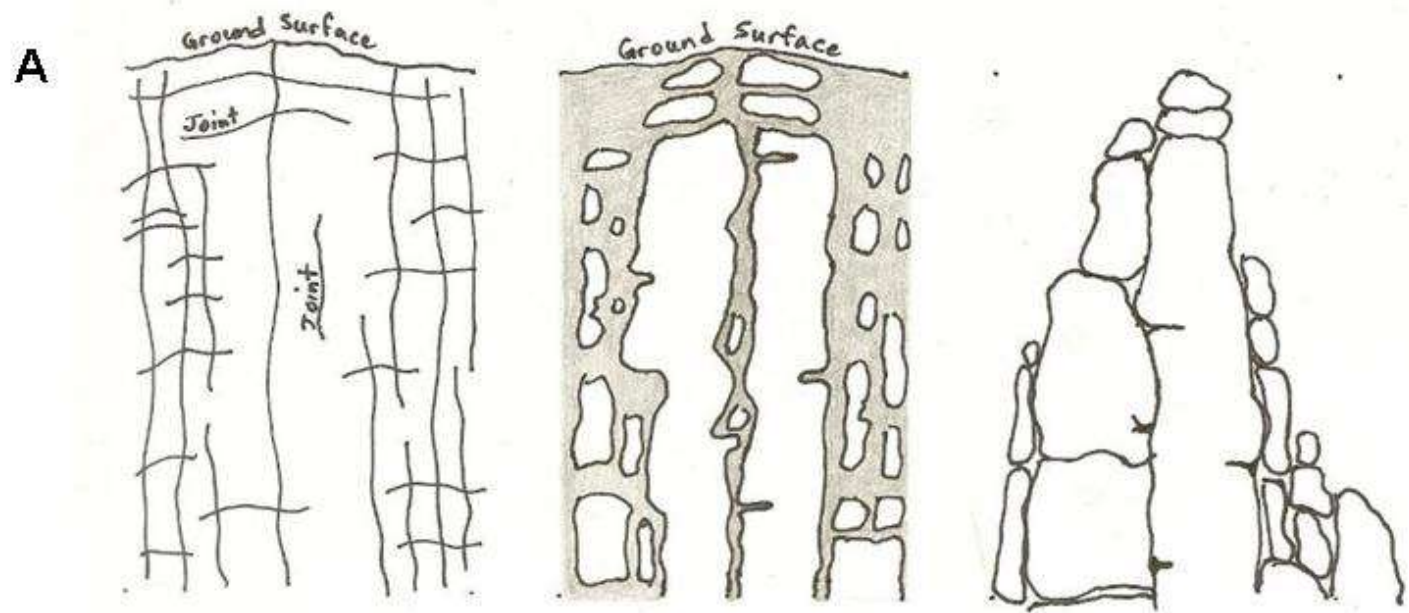


TORS CONTINUED

- **As weathering of tors continues, the rock is broken down further**
- **Hillsides are covered in loose rocks, known as clitter**
- **Eventually the granite is weathered down to a sandy gravel known as growan, which consists on individual crystals**
- **Tors are common in temperate climates**
- **Inselbergs in tropical climates**
- **Both suggest the removal of material by the way of solifluction**

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SLOPES



TYPES OF SLOPES:

3 main categories of slopes:

1. Concave – slope bends inwards
 2. Convex – slope bulges outwards
 3. Straight – when a slope has a vertical drop
- The formation of the slope is used to classify the slope:
 1. Tectonic slopes – formed through internal forces that result in folding, faulting or warping
 2. Erosion slopes – formed through the agents of erosion (rivers, glaciers and waves) produce valley slopes or cliffs.
 3. Depositional slopes – deposits of weathered material build up to form inclined surfaces.

PRIMARY VS. SECONDARY EROSION

Primary erosion slopes:


- Have developed from the erosion of land by water, wind, sea and ice.
- Examples are river gorges, sea cliffs

Secondary erosion slopes:

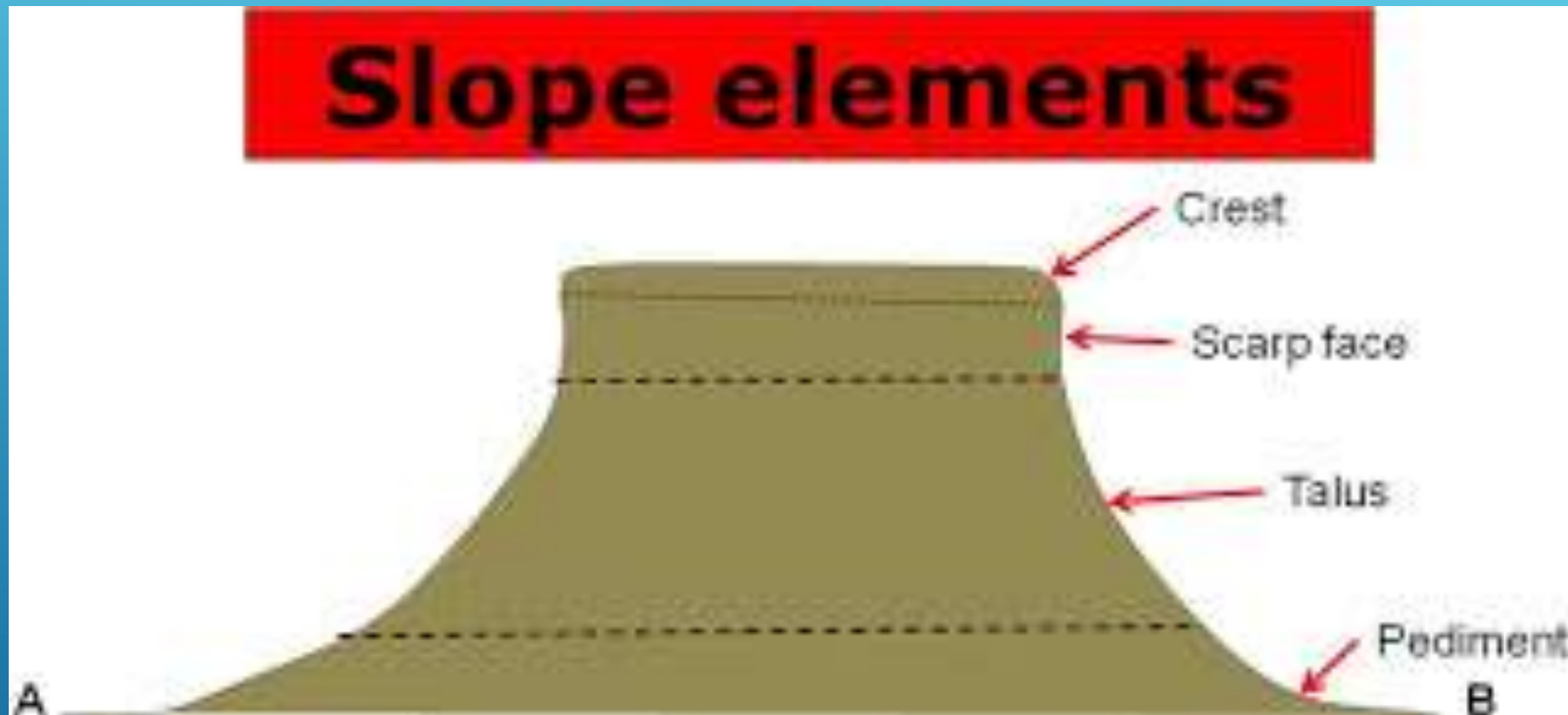
- Have developed through the weathering and erosion of primary slopes.

ENDOGENIC & EXOGENIC FORCES

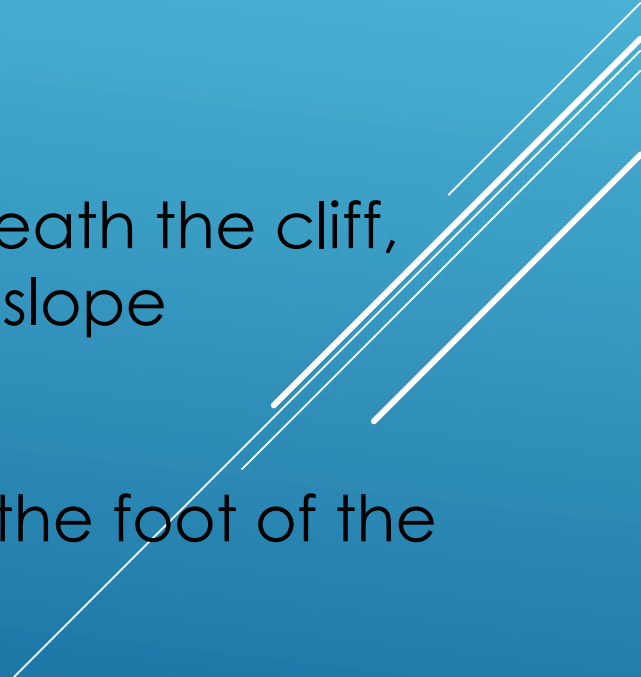
- **Endogenic forces – operate from the inside of the Earth’s crust to form or change rock**
 - **Tectonic uplift**
 - **Earthquakes**
 - **Volcanic activity**
 - **Folding/faulting**

 - **Exogenic forces – operate above or near the land surface and lead to either erosion or deposition.**
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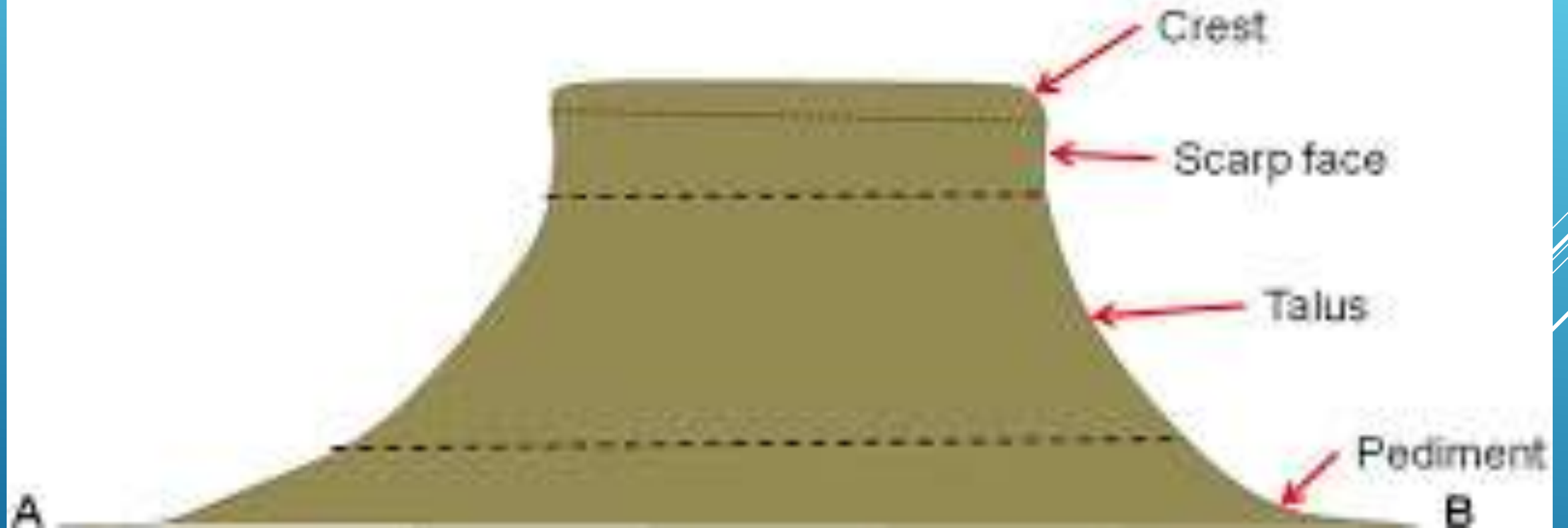
SLOPE ELEMENTS:



SLOPE ELEMENTS CONSIST OF:

1. The crest – convex slope usually found at the top of a hill, eroded material falls down the cliff.
 2. Cliff / scarp slope – steep almost vertical section of outcrop, often bears the scars of rock falls
 3. The Talus / debris –scree slope – less steep directly beneath the cliff, here material falls off the cliff and collects on the talus slope
 4. Pediment slope – low angle slope, slightly concave at the foot of the hill (bottom)
 5. Knick-point – sharp change in gradient
- 


Slope elements



SIGNIFICANCE OF SLOPES FOR HUMAN ACTIVITIES

- The cliff – poor soil quality and the steep gradient limit most commercial activities, however recreational activities such as rock climbing, hang-gliding or abseiling can be done.
- The Talus – due to rock falls from the cliff, it makes it too dangerous for any human activities
- The Pediment – of the 4 slopes this is the most user-friendly slope, it is flat so allows easy access for most commercial activities as the soil is of a good quality and can be built on.
- People alter slopes by mining, building roads and housing, or terrace farming.
- Vegetation helps protect slopes from erosion by binding the soil and draining surface water.
- Deforestation is a large contributor to soil erosion and, wire nets and metal reinforcements help stop rock falls and soil erosion.

ACTIVITY 10.1 Q 1-3 PG. 98
ACTIVITY 11.1 PG. 101

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SLOPE DEVELOPMENT OVER TIME & SLOPE RETREAT

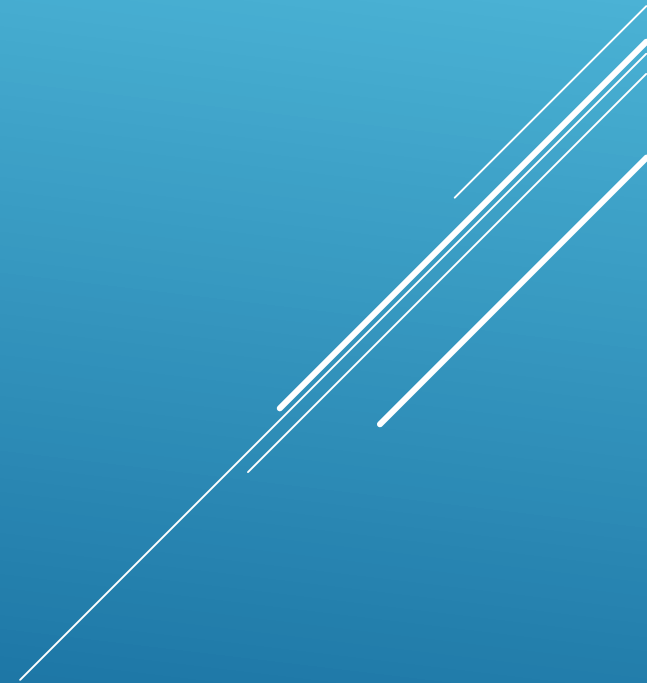


KEY TERMS:

- Peneplain – nearly flat plain formed by erosion of slopes in humid conditions
- Down wasting – erosion of the land mass in such a way landforms become lower over time
- Pediplain – nearly flat plain formed as canyon floors become wider in arid conditions
- Back wasting – erosion of the land mass in such a way that landforms become narrower
- Parallel retreat – erosion of the scarp slope causes loss of ground over the face of the slope, but not in height.
- Sheetflow – rainwater flows over a slope in a sheet

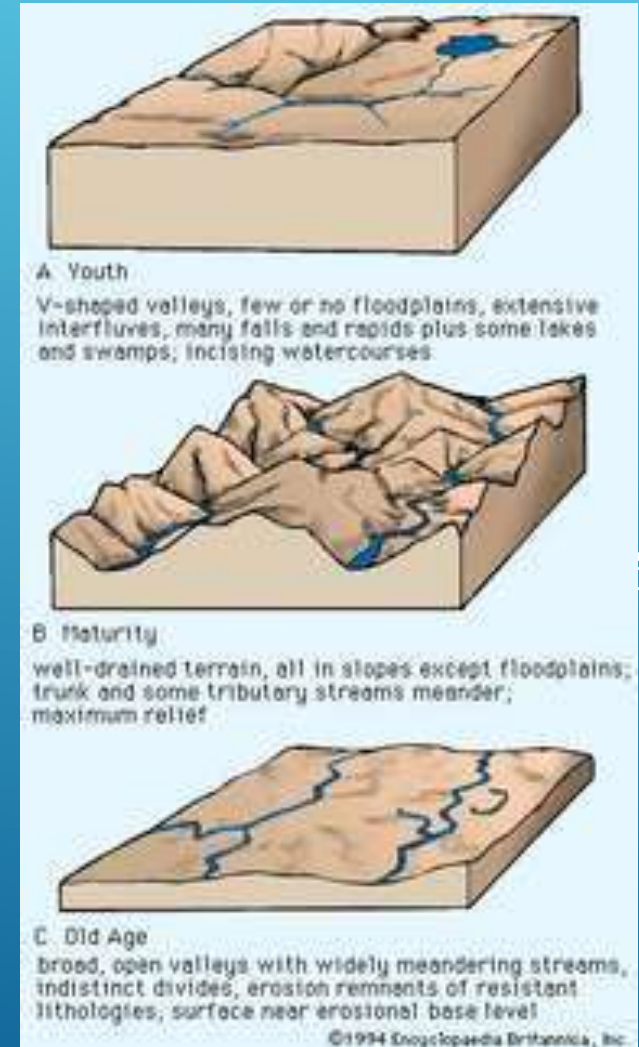
1. *SLOPE DEVELOPMENT OVER TIME*

- Flowing water, as it flows from high to low grounds, play a large part in shaping of slopes
- Landscapes go through a cycle of 3 stages while they erode from mountains into plains.
- These stages are:
 1. Youthful
 2. Mature
 3. Old age



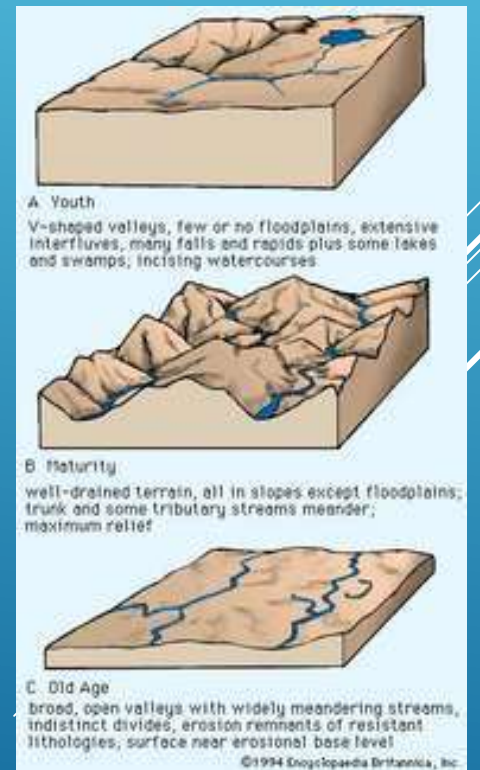
1. YOUTHFUL STAGE

- Sudden uplift of the surface raises the height of the land.
- Erosion starts immediately after uplift and carves narrow V-shaped valleys and canyons with steep slopes.
- The erosion is mainly downward erosion



2. MATURE STAGE

- Further erosion causes the mature stage
- Sideways (lateral) erosion widens the V-shape valleys and high lying areas become smaller and lower
- At first slopes are rugged, but become more rounded due to sheetflow



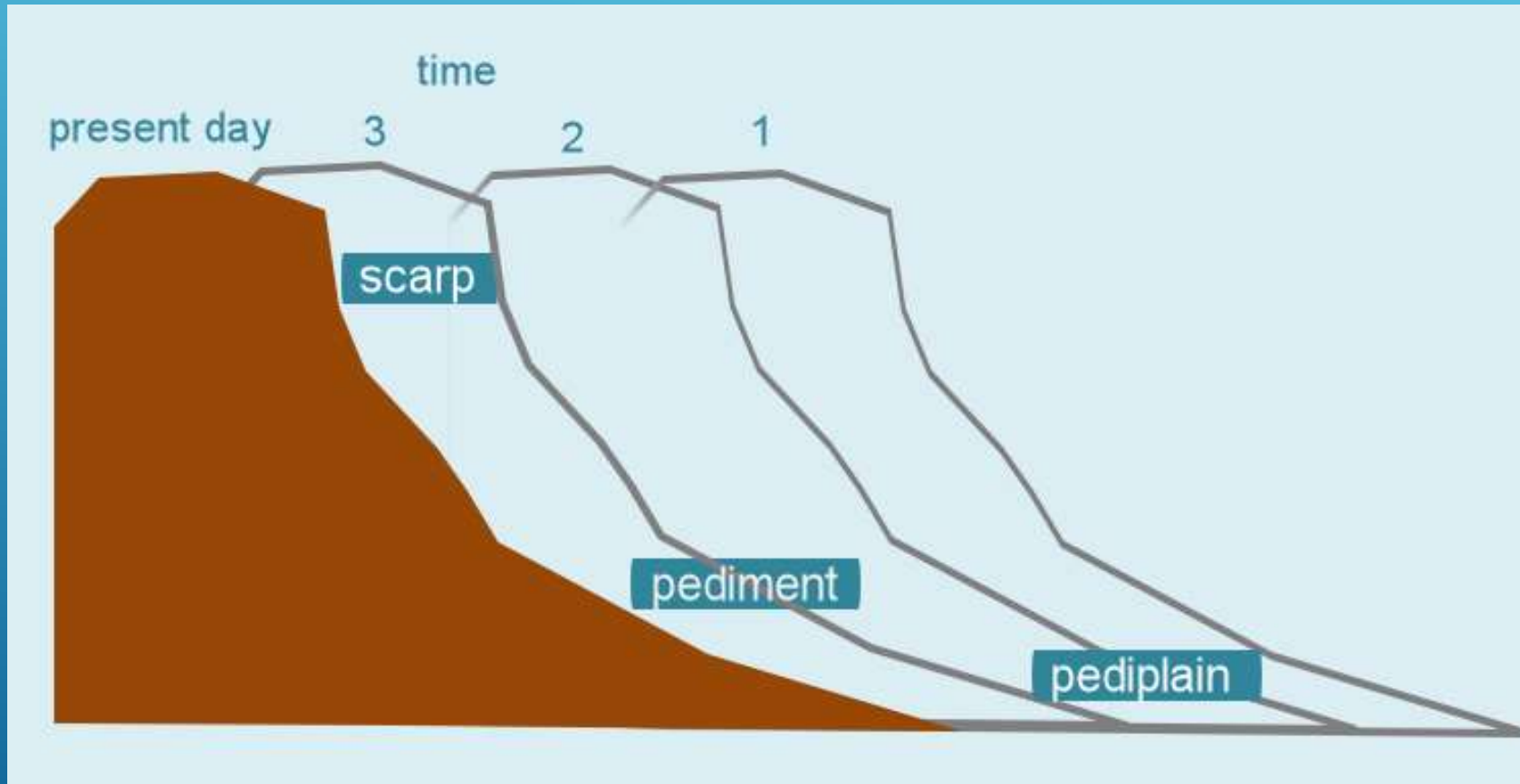
3. OLD AGE

- As erosion continues over time, valleys become wider and develop into floodplains.
- Streams meander to cause more lateral erosion.
- Deposition of material starts areas between rivers are smaller.
- Upper slopes are convex and lower slopes concave.
- The land is now almost eroded to a level plain



THE CONCEPT OF SLOPE RETREAT

Slope elements are eroded back parallel to themselves, they maintain their gradient and do not get lower



MASS MOVEMENTS AND HUMAN RESPONSE




CONCEPT OF MASS MOVEMENTS

- Mass movements / mass wasting or slope failure refer to all downward movement of weathered material such as soil, stones and rocks on a slope as a result of gravity.
- Mass movements can occur at a very fast or slow rate.
- Water is important in mass movements, less water the soil restricts mass movement as the soil has greater cohesion, large amounts of water will lubricate the weathered material assist in the mass movement.

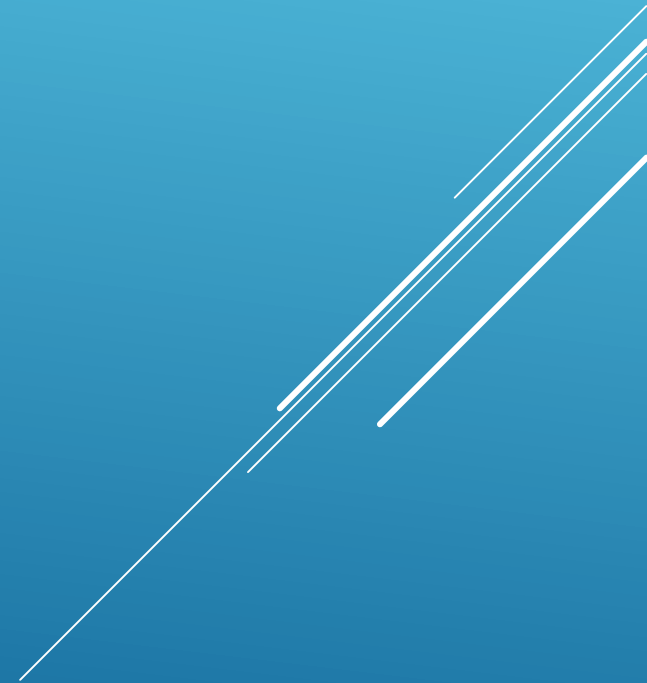
FACTORS INFLUENCING THE SPEED OF MASS MOVEMENTS

- **Gradient of a slope:** steeper the slope the faster the mass movement, slopes with an incline of 40 degrees or more are common for mass movements.
- **Rock structure:** Slopes that are made up of stratified rock of alternating strata of more resistant and less resistant rock are more prone to mass movements.
- **Vegetation:** Slopes with little vegetation are prone to mass movements as there are less roots to bind soils and more sheet flow from rain.
- **Soils:** soils that are thin have less vegetation, sandy soils move more easily downhill, soils that are not porous become saturated and move downhill
- **Climate:** Heavy rain adds volume and weight to soil which makes it unstable.

FACTORS INFLUENCING THE SPEED OF MASS MOVEMENTS

- **People:** peoples actions can trigger mass movements, deforestation, building on unstable hill slopes, slopes are excavated for roads making them unstable, mining or quarrying also increase mass movements
 - **Earthquakes and volcanic eruptions:** result in mass movements
- 
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TYPES OF MASS MOVEMENTS



TYPES OF MASS MOVEMENTS

1. Flows

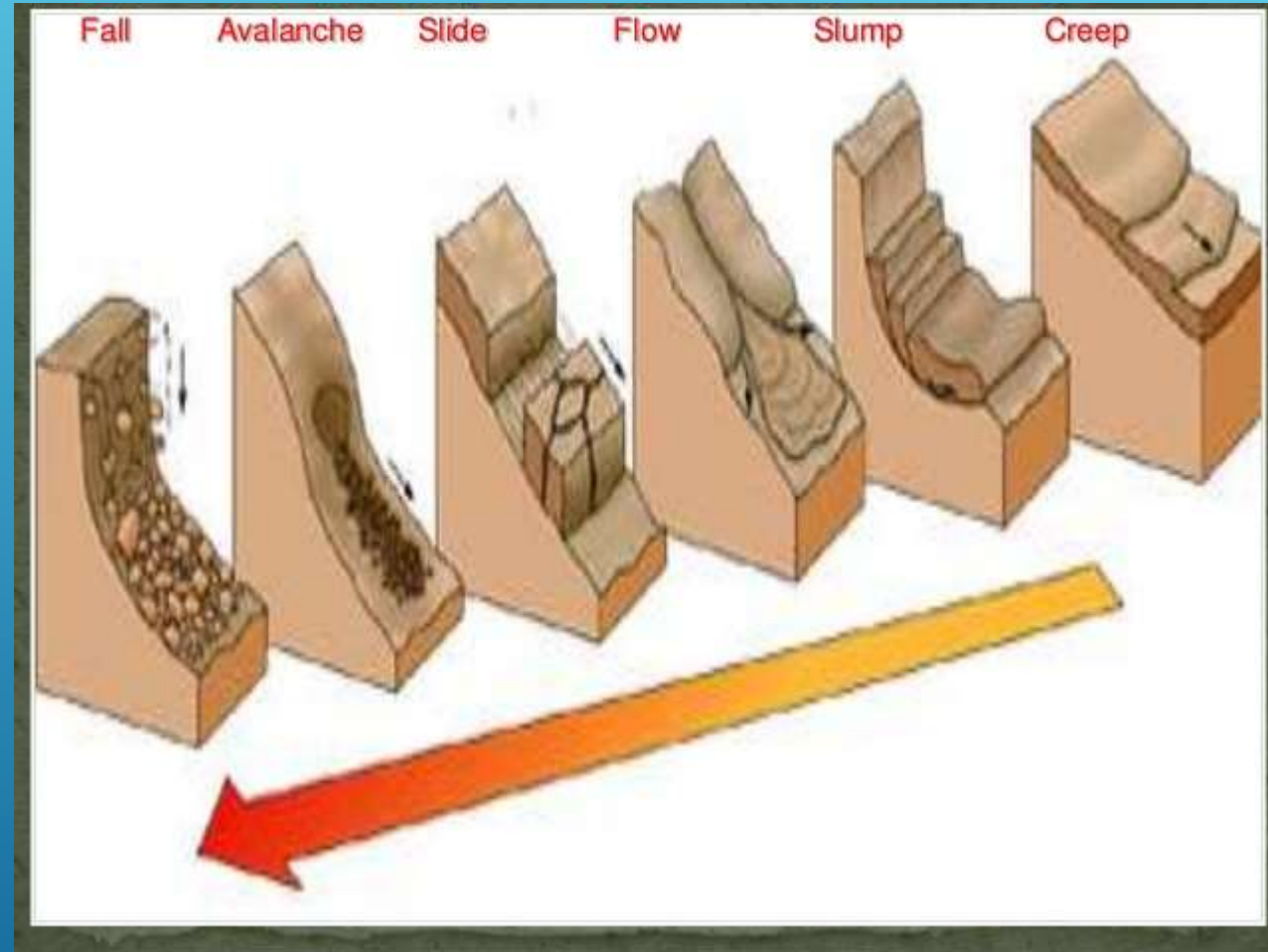
- Soil creep
- Solifluction
- Earthflow
- Mudflow

2. Slides

- Land slide
- Slumps

3. Falls

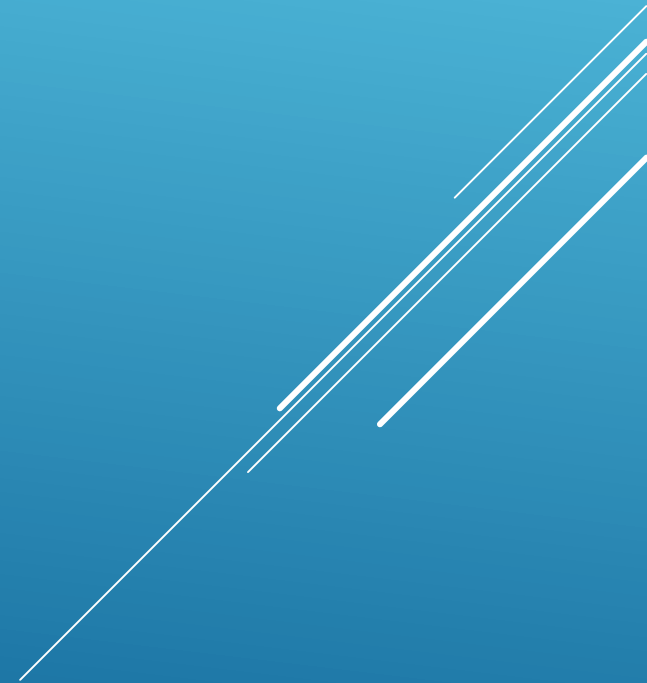
- Rock falls



1. FLOW

- **1. Soil creep**

- Slowest mass movement
- Moves at a rate of less than 1 cm per year
- Steeper the slope the fast the creep
- Occurs with soil expands or contracts due to wetting or drying
- Indications of soil creep are:
 1. Small steps called terracettes
 2. Curved tree trunks
 3. Bent fence posts
 4. Accumulated soil against structures





Aspen growth in Utah shows progressive soil creep downslope.

2. SOLIFLUCTION

- Occurs when top soil becomes saturated and slides on frozen ground beneath it
- It occurs a little faster than soil creep at 5cm per year.



3. EARTHFLOW

- Occurs in clay areas when soil is saturated with water
- Its moves down a slope with a fairly gentle gradient
- Speed is between 1 and 15 km per year



4. MUDFLOW

- More rapid than earthflow
- Speeds can exceed 1 km per hour but can be faster
- Occurs when streams of mud flow down a slope in definite channels.



2. SLIDES

1. Landslides and slumps

- Sudden movements occurring when a large mass of land breaks loose and plunges down a slope
- Can occur along a fault zone, when a block of land tilts backwards and slumps downhill.
- Earthquakes also trigger landslides



3. FALLS

1. Rock falls


- Occur when rock fragments break off from the parent mass as a result of weathering and fall to the bottom of a slope scree
- Most rapid movement




IMPACT OF MASS MOVEMENTS ON PEOPLE AND THE ENVIRONMENT



IMPACT ON PEOPLE


- **Death and injury to people**
 - **Property damage and loss of homes**
 - **Damage to transport infrastructure**
 - **Damage to agricultural lands**
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IMPACT ON THE ENVIRONMENT

- **Destroy vegetation and forests**
 - **Damage ecosystems and natural habitats**
 - **Block streams and dam up lakes**
 - **Remove topsoil and cause erosion**
 - **Change the nature of slopes**
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STRATEGIES TO PREVENT THE EFFECTS OF MASS MOVEMENTS

1. *Prevention*

- Planting vegetation
 - Controlling drainage down a slope
 - Concrete drains to lead run-off and prevent infiltration
 - Retaining walls
 - Rock bolts
 - Deeply sunk pylons
 - Wire cables and wire fences covering the area of danger.
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