4. External factors of morphologie

4.1. Types of erosion

The types of erosion can be classified according to the main agents: water (hydric, coastal, glacial), wind (aeolian), temperature variations (thermal) or human activity (anthropogenic).

4.2. Process of erosion

Erosion is a natural process involving the weathering and displacement of substances (soil, rock) by elements such as wind, water (rain, runoff, waves) and gravity. This process can be divided into three main phases: the breakdown of rock, its displacement and, finally, the accumulation of debris (sediment). Although erosion is a natural phenomenon, it is considerably intensified by human activities such as deforestation and large-scale agriculture.

The erosion process is complex and involves several stages :

a. Detachment:

Soil particles are detached from their original location. This can occur due to various factors such as rain, wind, waves, or water runoff.

b. Transport:

Particles are transported to other locations by erosive agents such as water, wind, glaciers or waves. The type of transport depends on the environment; for example, transport by water can occur through surface runoff or through watercourses.

c. Sedimentation:

When erosive agents lose their energy, the transported particles begin to settle. This sedimentation process can occur in rivers, lakes, oceans, or even on hillsides.

d. Compaction:

Deposited sediments often undergo a compaction process, where pressure from the upper layers causes the spaces between particles to shrink.

e. Weathering:

This process involves the disintegration or modification of the characteristics of rocks and soils under the effect of various agents such as changes in temperature, the chemical action of water or other substances.

f. Formation of geomorphological features:

Over time, erosion can shape the landscape by creating geomorphological features such as valleys, canyons, dunes, cliffs, etc.

4.3. Areolar erosion (WATER EROSION)

We refer to sheet erosion because the energy of raindrops is applied to the entire surface of the soil and the transport of loose material occurs through sheet runoff. This is the initial stage of soil degradation through erosion.

Sheet erosion can strip away most of the humus horizon in a few decades. The most obvious sign of sheet erosion is therefore the presence of light-coloured patches in the most eroded, most damaged areas of fields (hilltops and slope breaks).

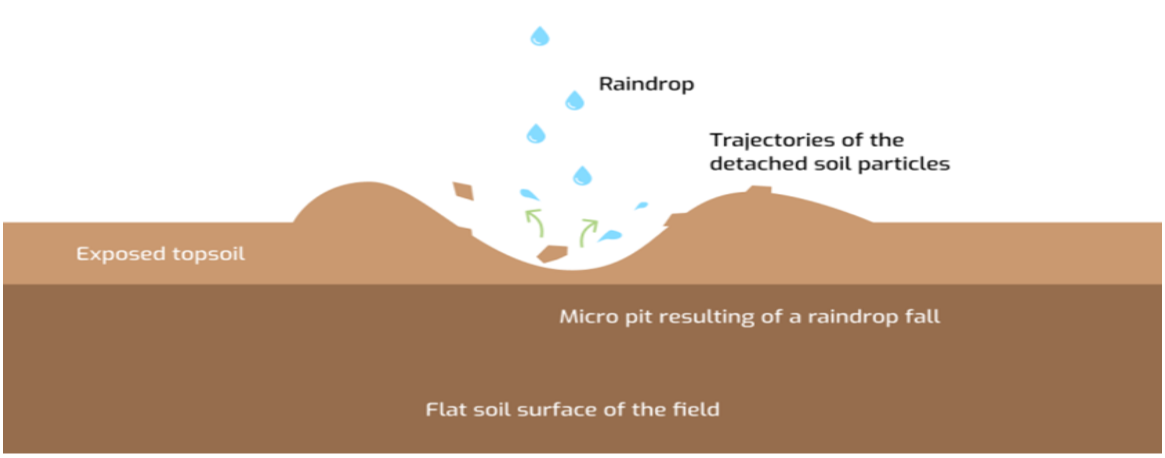


Figure: Water erosion

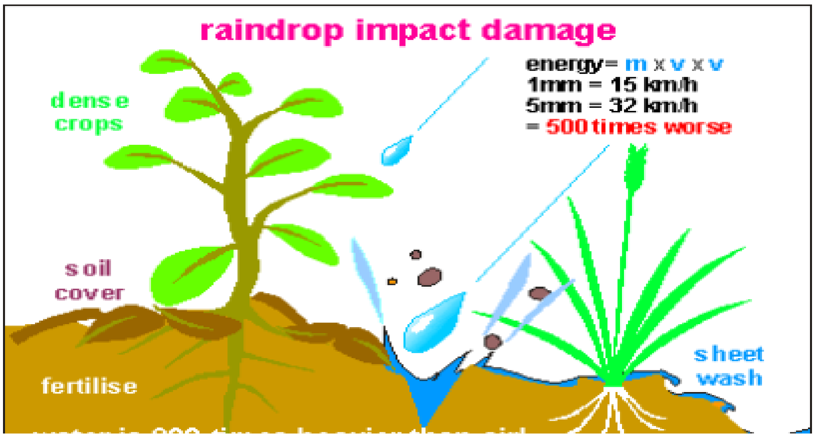


Figure : raindrop impact damage

This image illustrates soil erosion caused by the impact of raindrops, highlighting the importance of ground cover in mitigating damage.

Raindrops have considerable kinetic energy, which increases with the size of the drop.

The impact of raindrops dislodges soil particles, which can lead to sheet runoff and erosion.

Dense ground cover, such as crops or mulch, protects the soil by absorbing the energy of the impact.

4.4. Slope profiles

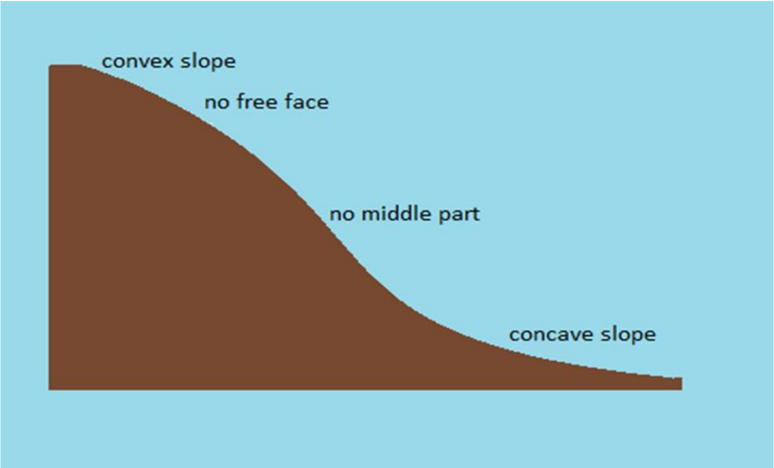
Longitudinal (or longitudinal) and cross-sectional (perpendicular to the hydrographic network) profiles are key elements in diagnosing the functioning of the watercourse and the relationships between the minor bed and the major bed.

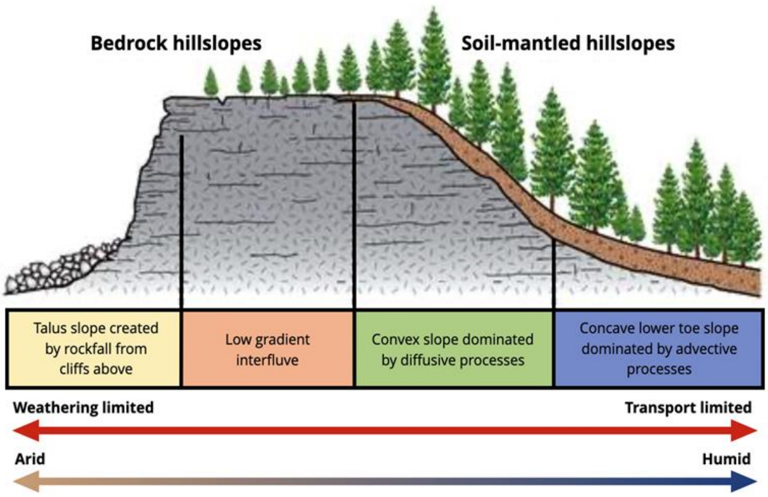
In geomorphology, a **slope** is an inclined topographical surface located between high points

(peaks, ridges, plateau edges, summits) and low points (foot of the slope, thalweg). The shapes of slopes (cross-sections) characterise valleys. The profile of a slope can be regular or irregular (i.e. with breaks in the gradient), depending on the lithology and the action of erosion.

A slope is defined by:

- ✓ **Topographical characteristics:** widths according to contour lines and cross-sections, elevation differences, slopes (average, extreme), longitudinal profile (regular (e.g. straight, combe) / irregular (e.g. presence of flat areas, fluvial terraces), sun exposure (south-facing / north-facing).
- ✓ **Surface characteristics:** geology (soil, rocky outcrops, scree, snow), vegetation (woodland, layering), human development (terraces, buildings/urban planning, etc.)





Slopes can have irregular or regular profiles.

- **Irregular profiles** appear when several rock layers outcrop or when the relief is shaped by landslides.

- **Regular profiles**, on the other hand, are smooth slopes, often covered with a layer of debris: stabilised scree at the bottom, weathered rock fragments at the top.

A slope covered with debris but still very steep is called a **Richter slope**, close to the slope of **the equilibrium slope**.

However, most slopes have a gentle slope, shaped by slow erosion (diffuse runoff, creeping, leaching). Their profile is generally convex at the top, straight in the centre, and concave at the bottom, where they gradually join the valley.

The shape varies according to the nature of the rocks (marked convexity on chalk or sand, dominant concavity on clays) and according to the climate (extensive glacis in arid and tropical regions).

These slopes are said to have an **equilibrium profile**, as there is a balance between:

* the **production of debris** (fragmentation),

* and its **removal**.

If one of the two processes were to dominate, the slope would either be denuded or buried under debris.

4.5. Linear erosion: terraces

Linear erosion is expressed by all linear depressions that cut into the soil surface in various shapes and sizes (claws, gullies, ravines, etc.). In fact, linear erosion occurs when surface runoff becomes organised. In a watershed or plot of land, gully erosion follows surface erosion due to the concentration of runoff in hollows. At this stage, the gullies do not converge but form parallel streams.

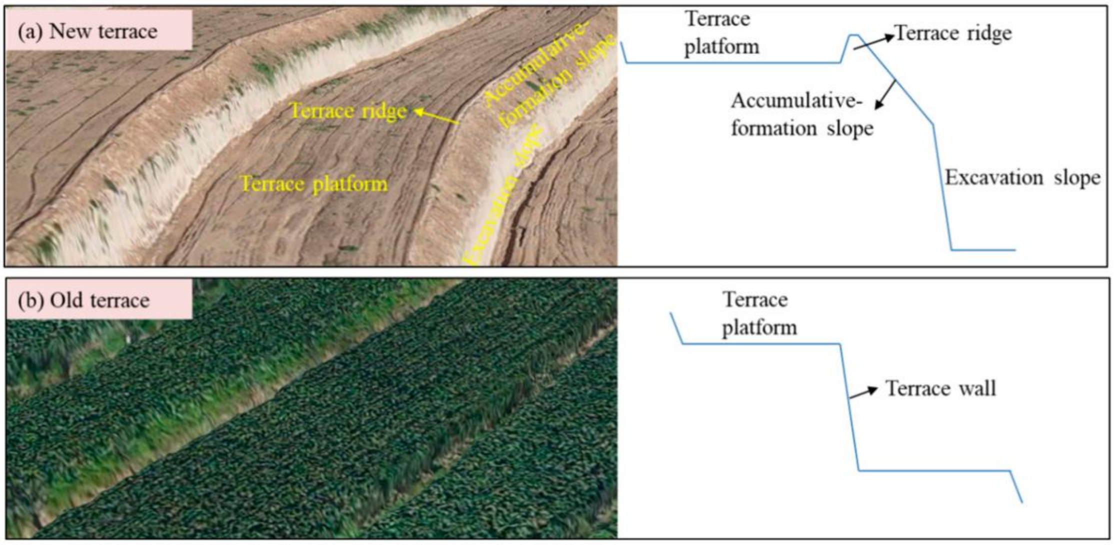


Figure : Linear erosion

4.6. Periglacial erosion

The term periglacial originally referred to areas close to glaciers, with a cold climate and freeze-thaw cycles. It now refers to all processes related to the freezing and thawing of soil, surface and rocks, even in the absence of glaciers. These dynamics occur mainly in **permafrost** (a layer of soil or subsoil that remains permanently frozen). Periodic thawing and freezing of permafrost contributes to erosion processes), but also during seasonal frosts. Glacial erosion acts in two ways:

Uprooting (plucking) : rock blocks, often along tectonic fissures, are uprooted and incorporated into the ice.

Abrasion: the bedrock is polished by sand and scraped by boulders, pebbles and gravel, forming rounded rocks and furrows. The water beneath the glacier also contributes to polishing and erosion, leading to the formation of U-shaped valleys on a large scale.

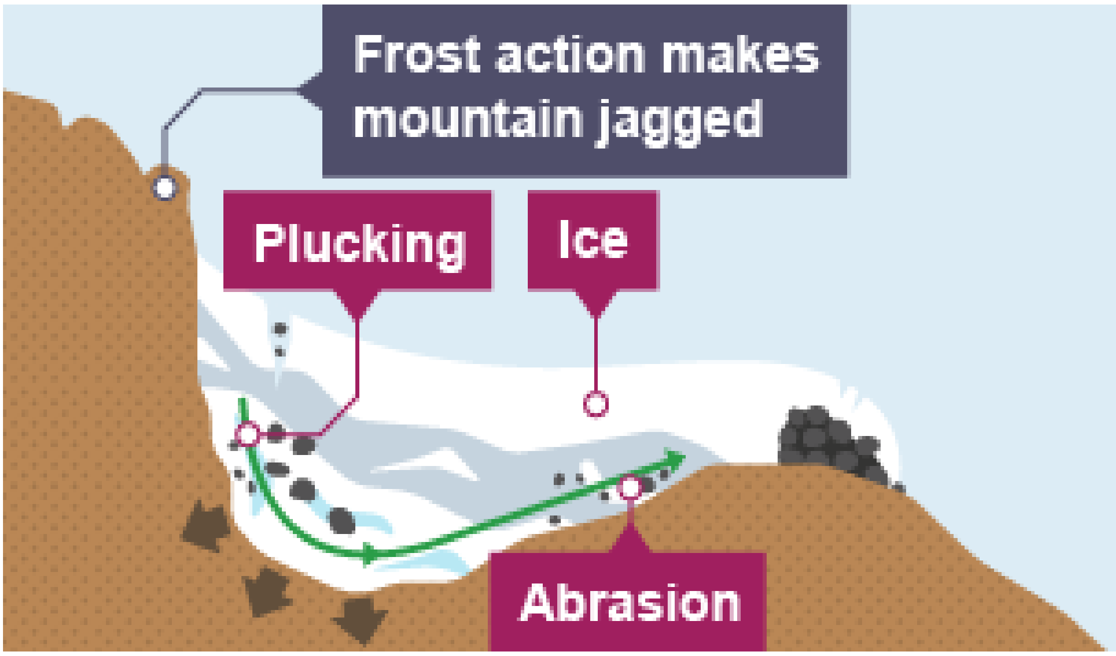


Figure : Periglacial erosion

4.7. Karst Model

The karst model concerns the erosion of soluble rocks (limestone, dolomite, gypsum) by groundwater. It includes an endokarst (underground network: caves, conduits, underground rivers) and an exokarst (surface features: sinkholes, canyons, dolines, lapiaz). Karst formation is based on the chemical dissolution of rocks by slightly acidic water (carbonic acid). It produces caves, networks of conduits, karst depressions (sinkholes, poljes), and speleothems (stalactites, stalagmites).

Karst landscapes influence hydrology, biodiversity and water supply, and are often spectacular.

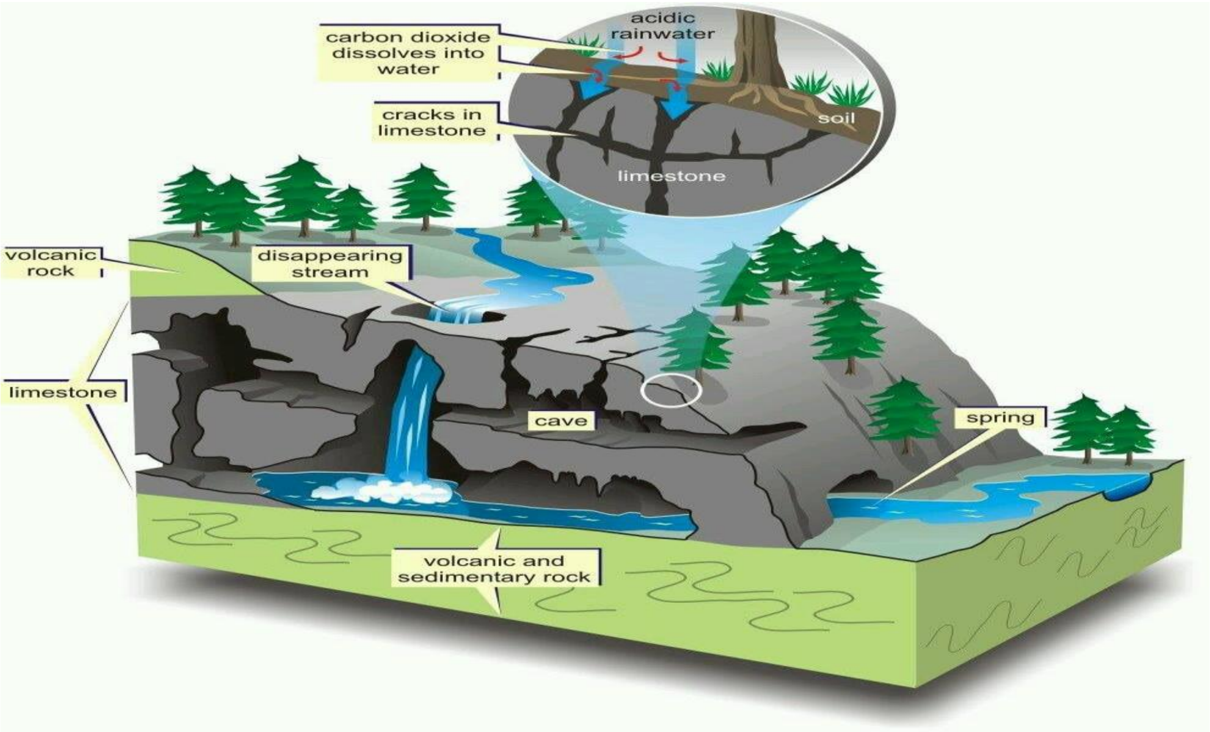


Figure : Karst Model

4.8. Wind erosion: wind formations

Wind erosion occurs in arid climates where rainfall is less than 600 mm on bare soils and in the presence of wind speeds exceeding approximately 20 km/h or 6 m/s on dry soils. It can also occur in humid climates when certain months of the year are particularly dry, especially when the soil is prepared using cultivation techniques that pulverize the soil surface.

The determining factor in the occurrence of wind erosion is primarily the erosive force of the wind acting on the soil surface.

The mechanisms of wind erosion

Saltation :is the movement by which particles measuring 0.5 to 1.1 mm make short jumps (often less than 30 cm high and 0.5 to 1 m long). This process is essential because it triggers two other modes of transport:

Creep: Larger particles (0.5 to 2 mm), too heavy to be lifted, roll or slide along the ground under the impact of the salting grains.

Suspension: Fine dust particles are thrown into the air by these impacts and then transported to great heights (up to 3,000–4,000 m) by updrafts.

Even though the clouds of suspended dust are spectacular, saltation remains the fundamental mechanism of wind erosion.

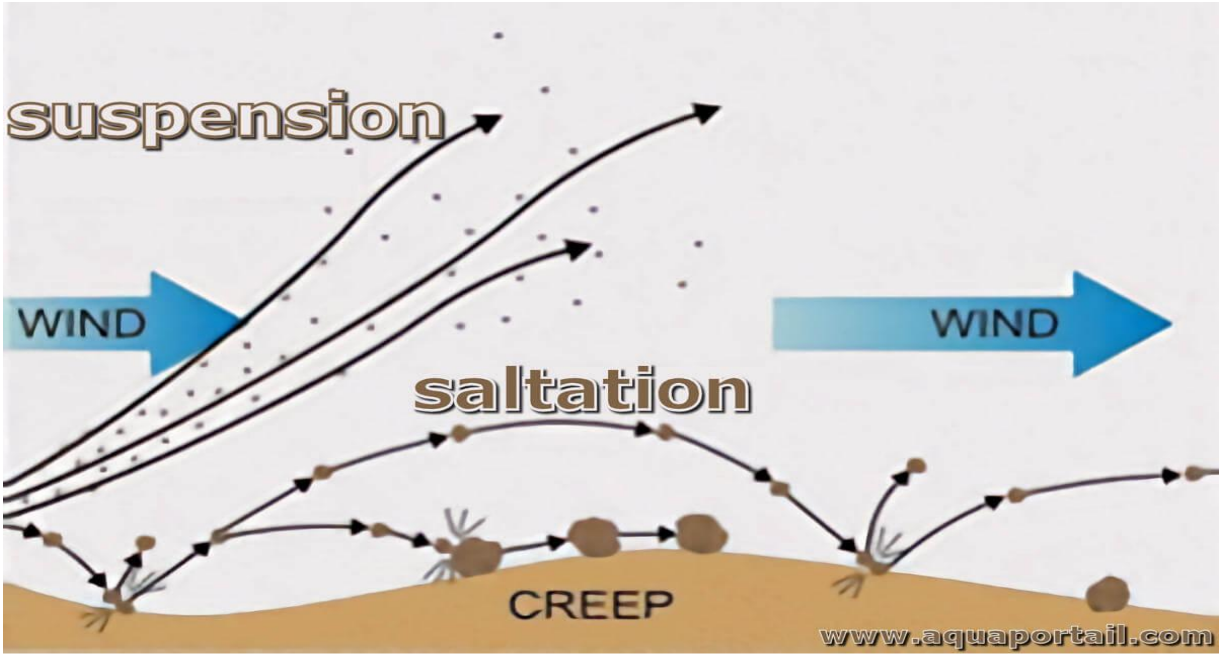


Figure : The mechanisms of wind erosion

4.9. Hydro-aeolian basins: Daya

Hydro-aeolian basins, or dayas, are closed, circular depressions, sometimes saline, formed by the weathering of rocks and the removal of fine materials by the wind. Their size varies from a few tens of meters to several kilometers. They temporarily collect rainwater and promote the accumulation of silt and clay, providing sufficient moisture for vegetation and sometimes productive agriculture.

In the context of renewable energy, these basins can serve as water catchment areas and be integrated into pumped-storage hydroelectric systems. Their morphogenesis results from both natural processes (weathering, wind erosion) and human interventions. They are comparable to depressions such as the sebkhas of North Africa and the Middle East.

Figure : The salt lakes of Sebkha between Batna and Ain M'Lila

4.10. Anthropogenic action and morphogenesis

Soil erosion is a major form of land degradation, along with compaction, loss of organic matter, deterioration of soil structure, inadequate drainage, salinization, and acidification. Although erosion is a natural phenomenon caused by water and wind, human activities greatly exacerbate it.

The conversion of forests into agricultural land or pastures reduces the protection offered by vegetation, which weakens the soil. The overgrazing of pastures by herds also damages the vegetation cover, accelerating erosion. Human infrastructures (roads, buildings, farms) further exacerbate this phenomenon, potentially turning it into a true national scourge.

The bio-erosion exerted by living beings on rock remains limited. On the other hand, human activities also generate anthropogenic pollution, notably CO_2 emissions responsible for climate change, and directly contribute to the degradation of landscapes thru deforestation, mining, or construction work.