WEATHERING & EROSION

Weathering

Rocks gradually wear away. This is called weathering. There are three types of weathering:

- physical weathering
- chemical weathering
- biological or organic weathering

Physical weathering

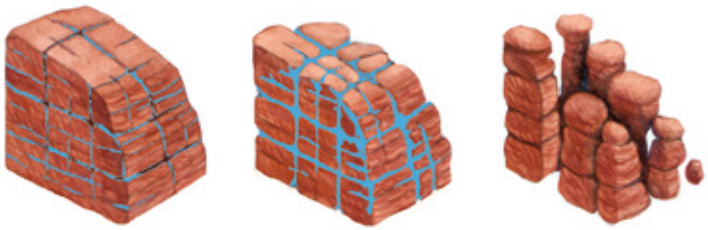
Physical weathering is caused by physical changes such as changes in temperature, freezing and thawing, and the effects of wind, rain and waves.

Wind, rain and waves

Wind, rain and waves can all cause weathering. The wind can blow tiny grains of sand against a rock. These wear the rock away and weather it. Rain and waves can also wear away rock over long periods of time.

Ice–freeze–thaw

Water expands slightly when it freezes into ice. This is why water pipes sometimes burst in the winter. You might have seen a demonstration of this sort of thing at school – a jar filled to the brim with water eventually shatters after it is put into a freezer.



The formation of ice can also break rocks. If water gets into a crack in a rock and then **freezes**, it **expands** and pushes the crack further apart. When the ice melts later, water can get further into the crack. When the rock freezes again, it expands and makes the crack even bigger.

This process of freezing and thawing can continue until the crack becomes so big that a piece of rock falls off.

Temperature changes

When a rock gets hot it **expands** a little, and when a rock gets cold it **contracts** a little. If a rock is heated and cooled many times, cracks form and pieces of rock fall away. This type of physical weathering happens a lot in deserts, because it is very hot during the day but very cold at night.

Biological/organic weathering

Animals and plants can wear away rocks. This is called **biological or organic** weathering. For example, burrowing animals such as rabbits can burrow into a crack in a rock, making it bigger and splitting the rock.

You may have seen weeds growing through cracks in the pavement. If you have gone for a walk in the countryside, you may even have seen bushes or trees growing from cracks in rocks or disused buildings. This is because **plant roots** can grow in cracks. As they grow bigger, the roots push open the cracks and make them wider and deeper. Eventually pieces of rock may fall away.

People can even cause biological weathering just by walking. Over time, paths in the countryside become damaged because of all the boots and shoes wearing them away.

Chemical weathering

The weathering of rocks by chemicals is called chemical weathering. Rainwater is naturally slightly acidic because **carbon dioxide** from the air dissolves in it. Minerals in rocks may react with the rainwater, causing the rock to be weathered.

Some types of rock are easily weathered by chemicals. For example, **limestone** and **chalk** are made of a mineral called calcium carbonate. When acidic rainwater falls on limestone or chalk, a chemical reaction happens. New soluble substances are formed in the reaction. These are washed away and the rock is weathered.

Chemical weathering can hollow out caves form and make cliffs fall away.

Some types of rock are **not** easily weathered by chemicals. For example, **granite** and **gabbro** are hard rocks that are weathered only slowly. Still some of their minerals do react with the acids in rainwater to form new, weaker substances that crumble and fall away.

Granite, a hard wearing rock.

Marble Arch Caves, Co Fermanagh.

Acid rain

When fossil fuels such as coal, oil and natural gas are burned, **carbon dioxide** and **sulphur dioxide** escape into the air. These dissolve in the water in the clouds and make the rainwater more acidic than normal. When this happens, we call the rain '**acid rain**'.

Acid rain makes chemical weathering happen more quickly. Buildings and statues made from rock are damaged as a result. This is worse when the rock is limestone rather than granite. (bbc.co.uk/bitesize/ks3science).

Statues damaged by acid rain.

Erosion and transport

Erosion

Weathering and erosion are often confused, so be careful when answering questions about them.

> Weathering is the wearing away of rocks.
>
> Erosion is the movement of the broken pieces away from the site of weathering.

For example, a basalt cliff may be weathered by freeze-thaw, a type of physical weathering. This means that pieces of the cliff may break away.

Erosion happens when these pieces of rock fall away down the cliff.

See the next page for a summary of the six main erosion processes.

In this photograph you can see a basalt cliff. At the bottom there are heaps of rocks, caused by weathering then erosion.

Transport

Rivers and streams can move pieces of rock. This is called **transport**. Fast flowing rivers can transport large rocks, but slow moving rivers can only transport tiny pieces of rock.

As the pieces of rock are carried along by the water, they bash against each other and the river bed. They gradually wear away because of this. They become smaller and more rounded. (bbc.co.uk/bitesize/ks3science).

Summary sheet: Six main erosion processes

Erosion Process	Description
gravity	Gravity is a passive force that moves what has already been loosened by weathering. Though not an active eroding force like wind or rain, the constant pull of gravity toward the center of the earth is what makes rocks fall from mountains and sand settle to the bottom of oceans. Gravity is a factor in all patterns of deposition of weathered material. For example, mountains are often surrounded by scree, loose rock debris fallen from exposed rock.
wind	When carrying dust and sand, the wind is a tremendous sculptor of the earth. Not only does wind erode rock, wind also carries away the sand and dust it creates in the process. Anything in the way of sand- and dust-carrying wind will be slowly weathered and eroded away. The sand breaks up whatever surface it encounters, just like sandpaper, and then the wind blows the freed material to another location. Examples are found wherever persistent winds occur. Such winds not only shape rock, but also can scour paint off barns and houses and lift valuable topsoilfrom one place and deposit it in another.
rain	Precipitation works to erode the land on which it falls through rainsplash erosion, rain splashing down on the land and dislodging weathered material such as pebbles or soil. Heavy rainfall, or large amounts of melting snow or ice, can also carry away the sediment into streams and rivers. The rivers continue the process, carving watersheds where the land is steep and enriching floodplains where the land is flat.
rivers	Though rivers and streams weather and erode the earth, they also build it up by depositing the material they erode downstream. The way in which it is deposited creates the typical shape of a meandering river. A river slowly winding its way through flat land flows a little bit faster on the outside riverbank than on the inside riverbank. This gives the water on the outside curve more power to weather the ground on that riverbank, extending and deepening the river in that direction. The slower water on the inside curve tends to deposit material carried by the river from the previous curves, adding material to the inside riverbank. In this way, a meander is expanded sideways, producing a deeper curve in the river. At the end of its course, a river deposits much of the remaining sediment at its mouth. If the sediment is not carried away into the ocean by the river current or by ocean tides, it remains and builds up, eventually expanding the mouth of the river by creating islands and sandbars, to make a river delta. The river is then forced to branch out into smaller streams to flow across the delta and into the ocean.

oceans	When it blows across the ocean, the wind creates waves that erode the loose sand on beaches. The repeated motion, often many times a minute, washes the beach sand back into the ocean. The rising and falling tides allow the waves to work on higher and lower elevations of the shore, removing material from different levels. Efforts by humans to protect shorelines from erosion by building rock walls often fail, as the energy of the ocean is transferred to more vulnerable areas, increasing erosion there. The actions of waves are heightened during a storm surge, a dome of water that accumulates under a major storm and is then driven onto the land by high winds. The high water level created allows the waves to reach further inland than usual, and the wind causes bigger than normal waves. The combination can be devastating to the shoreline, especially at high tide when the waves can be pushed even further inland. Oceans also erode the land with currents. As an ocean current moves past the shore, it picks up sand washed off the beach by the waves and sweeps it downstream, depositing it wherever the current slows down. The area with its beach washed away is left more vulnerable to wave action. On the other hand, downstream areas that receive the sand from the currents are bolstered and protected from wave action. In this way, the shoreline evolves naturally.
glaciers	With their enormous size and weight, continental glaciers weather and erode significant portions of continents, and alpine glaciers can weather and erode entire valleys. The enormous weight of the glacial ice and the embedded debris causes a glacier to weather the rocks beneath it as it flows, picking up still more debris along the way. As many glaciers in the world illustrate, the rock, sand, and clay debris is then deposited at the tip of the glacier as the glacier breaks off or retreats.

(taken from North American Montessori Centre)

Environmental impact of weathering & erosion — coastal erosion

Coasts are shaped by the sea and the action of waves. The processes that take place are erosion, transportation and deposition.

The action of waves

The **power** of waves is one of the most significant **forces** of coastal change. Waves are created by **wind** blowing over the surface of the sea. As the wind blows over the sea, friction is created — producing a **swell** in the water. The energy of the wind causes water particles to rotate inside the swell and this moves the wave forward.

The sea shapes the coastal landscape. Coastal erosion is the wearing away and breaking up of rock along the coast.

Coastal erosion is a term for the removal of beaches or dunes by waves, tidal currents, wave currents, or drainage. Waves, caused by storms and wind cause coastal erosion. On rocky coasts, coastal erosion results in dramatic rock formations in areas where the coastline contains rock layers. Softer areas become eroded much faster than harder ones, which can cause things like tunnels, bridges, columns, and pillars.

Sea stacks of chalk; The Needles, Isle of Wight.

Happisburgh, Norfolk, is now a coastal village; several hundred metres of land has been lost to the sea over the last 400 years.

Sea stack of basalt; The Lord, Islandmagee.

Environmental impact of coastal erosion

Coastal erosion is a natural occurrence, but is a steadily advancing threat to coastal areas because of climate change and human activities. As climate change occurs, rocky coastlines are increasingly threatened by extreme weather such as storms and higher water marks due to warming temperatures. Coastal erosion impacts humanity and the environment in various ways.

- **Property loss —** The most visible impact of coastal erosion is property loss. As the coastline is remapped by erosion, coastal properties are put at risk.
- **Tourism —** The tourism industry can be heavily impacted by coastal erosion. Many communities rely on revenue from summer tourism. When beaches are swept away, these communities can be financially devastated. Usually, coastal currents drag in sand that replaces what they sweep away, but coastal development has halted the cycle in some areas. Structures that are built along the coast collect the sand that comes in with the tide, preventing currents from sweeping it to beaches down current.

- **Environmental degradation —** Coastal erosion occurs naturally, and the slow wearing away of coasts can have ecological benefits, eg erosion can create inlets and feeding grounds for aquatic communities. However, unnatural processes driven by human action, including climate change, speed erosion and harm the environment.

Preventing coastal erosion

This is an overview of the different types of defences that can be used to help stop an area of a coast being eroded. These are some of the main methods used to try and prevent coastal erosion. Some of the defences are more effective than others at stopping erosion. Some may be very expensive. Some may be ugly and spoil the environment.

Armour blocks – Huge blocks of hard rock. Layered on the beach or at the bottom of a cliff. Stops the power of the waves. Relatively Cheap. They look ugly.

Breakwater walls – Walls of rocks built offshore away from the coast. They weaken strong waves before they reach the coast. Very expensive and difficult to build. People can still use the beach.

Gabions – Steel mesh cages filled with mixed stones. Absorbs the energy of waves. Cheap to build and easy to maintain.
Spoils the look of the coastal area.

Groynes – Wooden/stone fences built into the sea. Allows pebbles/sand to build up behind them and create a beach.
People can use the beaches.
Expensive to build.

Revetments – Wooden walls made of water-resistant wood. Blocks waves and stops sand being washed away. Cheap and easy to build. Very Ugly.

Seawall – Huge sloping walls of concrete. Stops all waves power to erode. Extremely expensive. Most effective defence at stopping erosion. Generally used to protect buildings or roads.

Beachfeed – Tonnes of sand is dropped on a coast to form a 'fake-beach'. Beaches look nice and can be used by tourists. Sand is cheap. It needs constant maintenance as much of the sand gets washed away and needs replacing.